CHILD LOCATOR

Service Manual

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AUTHORS:
JEREMY DAY
JOSHUA DAY
GARY SHIVES
RICHARD BEVINS
ISRAEL HALL

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INTRODUCTION

The Child Locator is composed of two or more devices, the parent and up to four child devices. The Child Locator uses GPS technology to acquire both the parent and child devices' location. Using GPS technology allows the Child Locator to be a versatile child location system. It can operate in any outdoor environment in the world. In order to achieve the range of operation needed, the Child Locator uses spread spectrum transceivers that give a large range of communication. The transceivers operate at 2.4Ghz, where few other wireless communication devices operate. This allows for fewer communication problems with other devices using the same frequency band. The Child Locator is a true stand-alone device that doesn't require any centralized computer or special hardware to be set up in the area of use.

The Child Locator uses a GPS to acquire the parent and child device's location. Once the parent longitude and latitude coordinates have been determined, it is then sent to the child device by the transceiver to calculate the relative distance and location from the parent. The child device then sends the distance and direction back to the parent device by the transceiver. Once the parent receives the child devices' distance and direction, it is then displayed on the parent device's display. This process is repeated for each child. Within the transmissions between the parent and child devices', the out of range and panic information is also sent within the transmission.

This manual is broken down into four main sections. The first section is an overall system description. It covers the flow of information within and between the parent and child devices. The next section is a more detailed look into the child locator. It describes the components that make up each device and includes complete schematics and printed circuit board (PCB) layouts. Following this section, there is a complete explanation, including brief troubleshooting tips, concerning the software embedded on the programmable integrated circuit (PIC). The last section breaks down each aforementioned subsystem in a detailed

troubleshooting point of view. Within this section are expected outputs from each subsystem device along with tips to what may be causing the child locator to malfunction.

SYSTEM DESCRIPTION

Parent Device

The parental device functional block diagram is shown in *Figure 1*. This block diagram shows the communication links and the flow of information within the parent device. Below is a list of each functional block within the figure. Each block in the list is described by its communication with other functional blocks.

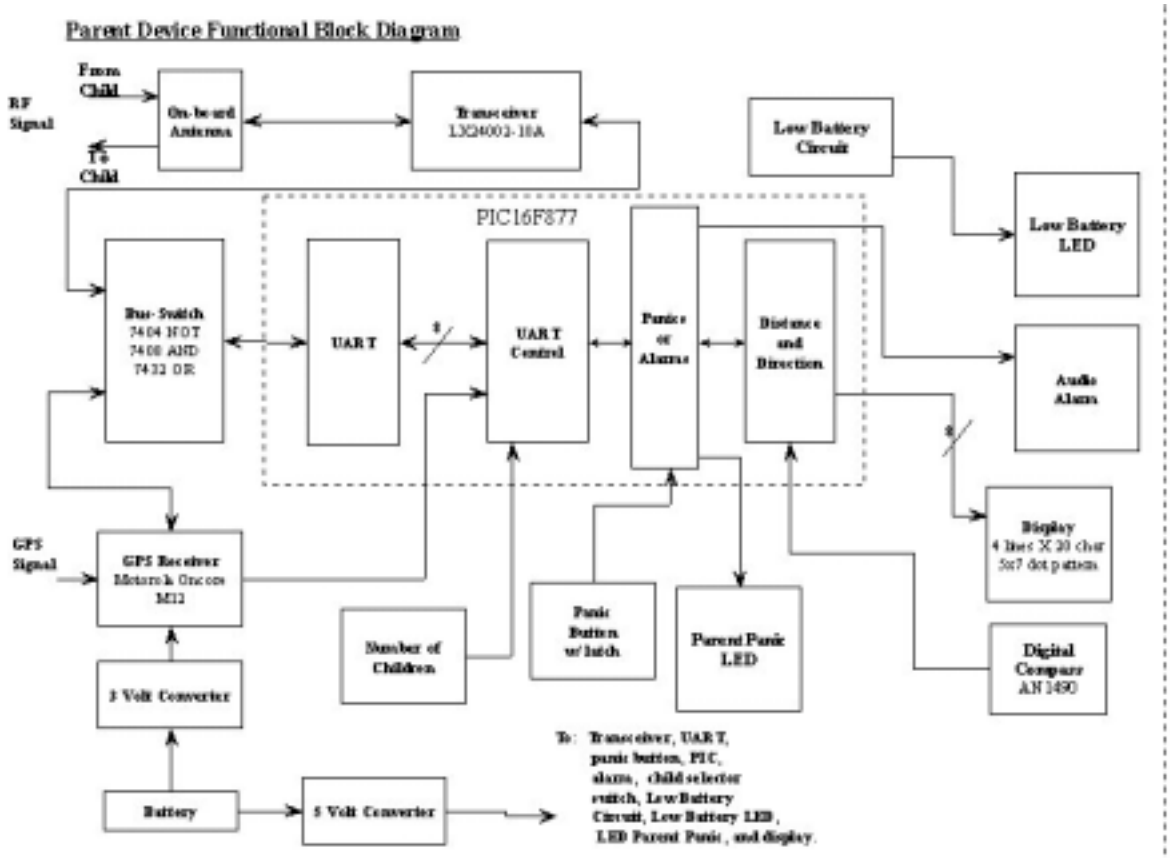


Figure 1 – Parent Block Diagram

- *Antenna and Transceiver:* These blocks work together to form the communication link between the parental unit and the child unit. Transmission from the parent to the child units is comprised of the

parent's longitude and latitude coordinates. In response, the child unit transmits panic information along with the distance and direction from the parent.

- *UART*: The information received from the child device and GPS receiver travels along a serial link through the UART to form an eight-bit bus. This data then travels into the first of three software components within the PIC16F877.

- *Panic Button*: This block represents a button that the parent can push to engage or disengage the alarm mechanism. The panic request travels into the software where the panic state is analyzed. The panic state is then stored and transmitted along with the next poll-children request.

- *Number of Children*: This block is used for the parent to enter the number of children at the start-up or to change the number of children during operation of the parental device.

- *GPS receiver*: This block receives a RF (radio frequency) signal, which it analyzes in order to determine it's own location and the current time of day. This data determined by the GPS unit will be sent serially through the UART and stored by a software component.

- *Bus-Switch*: This block will determine if the data entering the UART is communicating with the transceiver or the GPS unit.

- *Coordinate Manipulation*: This block will first check the child selector switch to determine the number of children. This block will then start polling the children through the transceiver. It will gather and store both the parent and child GPS coordinates.

- *Panics or Alarms*: This block will check the data received from the child through the transceiver for the child's panic state. A child's panic state is considered "on" under any of two conditions: if the child is out of range of the parent and/or if the child has pressed their own panic button.

- *Distance and Direction*: This block takes the child information received by the transceiver uses the digital compass to update the direction. It then displays the child information on the display.

- *Display*: This block contains a display for the parent, which shows the distance and direction to the child(ren).

- *Audio Alarm*: This block contains an alarm to notify the parent that a child is in a panic state.

- *Parent Panic LED*: This block contains an LED that will turn on when it receives a signal from the PIC. The only time it will receive a signal from the PIC is when the parent presses the panic button on the parent device. It will only turn off when the panic button is pressed again.

- *Digital Compass*: This block contains a compass, which will constantly provide the direction the parent is facing. This information is passed directly to the PIC16F877.

Child Device

The child unit is represented by the block diagram shown in *Figure 2*. This diagram displays all major components and the flow of data through the child device.

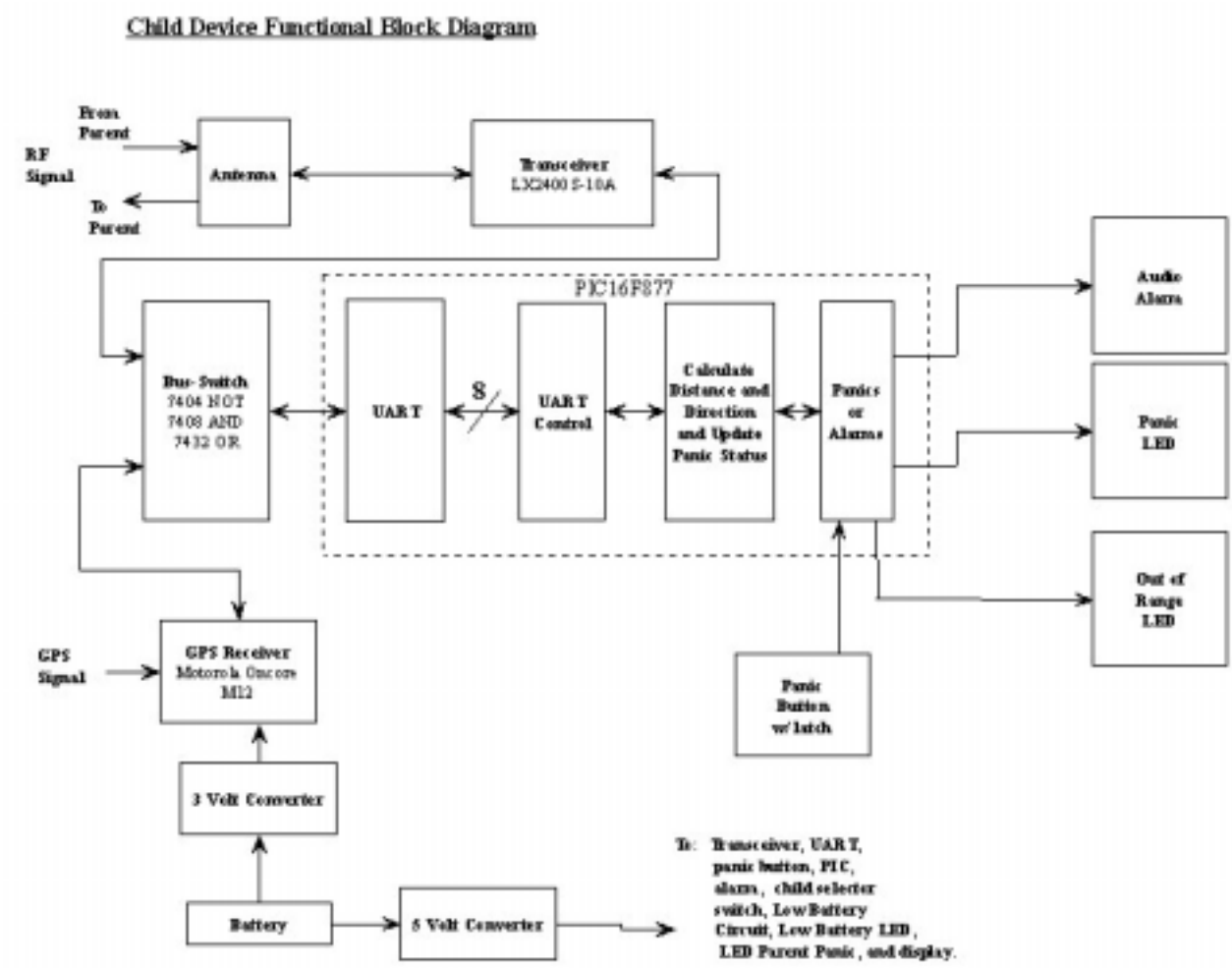


Figure 2 – Child Block Diagram

**All blocks except the software components have the same description as given for the parent block diagram.*

- *Calculate Distance and Direction and Update Panic Status:* This block first gathers the child's current GPS coordinates. Next, the block calculates distance and direction relative to the parent's location. It gathers panic information from the latching panic button and delivers this information to the UART for transmission to the parent.

- *Panic LED*: This block checks the "panics or alarms" functional block to see if any panics-requests have been sent. If, in fact, a panic-request has been sent, the LED will turn on.

- *Out of Range LED*: This block checks the out-of-range bit in the data received from the parent. If the bit is set (value = 1), the LED will turn on. The LED will only turn off when it is determined that the child is no longer outside the range of the parent's device.

SYSTEM COMPONENTS

This is a brief description of each device in the circuit schematics to follow. The purpose of this section is not to explain in detail how each device interacts but more as an introduction to the components in the following schematics and circuit board layouts. A more detailed analysis will follow.

5 VOLT REGULATOR, 3 VOLT REGULATOR: These chips are used to convert the ~ 9V DC voltage to appropriate voltage levels for our devices.

- The 5 Volt regulator is a 7805 chip and requires a minimum of 7.2 volts to reliably output 5 volts.
- The 3 Volt regulator is an LM317T chip that reduces the voltage from the batteries to 3 volts. This chip requires at least a 5.2 volt input to reliably maintain a 3 volt output.
- The 3 and 5 volt power busses are located on the printed circuit board of the parent and the perforated circuit board of the child.

PIC16F877: *This is a MicroChip programmable IC that controls the inputs and outputs from each device.*

- The chip is equipped with multiple I/0 ports and one serial port used for communicating between the GPS receiver and the transceiver.
- This device uses a 20 MHz crystal to set the clock speed of the device.

LX2400S-10A TRANSCEIVER: *The transceiver is used as the communication link between child and parent devices.*

- The transceiver used in our devices is the Aerocomm AC1524C-10A (LX2400S-10A).
- The transceiver is capable of communicating at speeds up to 115,200 bps, but both the parent and child devices are designed to communicate at 9600 baud.
- The range of the transceivers are 3000 ft. outdoors and 300 ft. indoors.
- The transceivers need a voltage source of 5V $\pm$ 2%. This is one of the main purposes of the voltage regulation circuit.

- The transceivers typically sink 115mA (each) and have a typical output power of 11mW.
- The transceivers operate in the 2.402 - 2.478 GHz frequency band.
- Transmission sequence to the transceivers must be in the following format: 5555553A"*length""data"* where length is the 32-bit integer representing the number of bytes of *"data"*.
- Information received from the transceivers is in the format *"length""data"*.

MOTOROLA ONCORE M12 GPS RECEIVER: *The GPS receiver receives information from GPS satellites to triangulate its longitude and latitude coordinates.*
- The receiver requires at least 2.8 – 3.2 volts to operate.
- Requests for position and position output from the receiver is sent through a serial connection at 9600 baud in Motorola Binary format.
- Requests *must* be sent using 3 Volt logic.
- Transmission for the receiver use 3 Volt logic.

7404 NOT, 7408 AND, 7432 OR: *These three TTL logic chips make up the bus switch.*
- The bus switch receives inputs from the PIC to switch serial communication between the GPS receiver and transceiver.

LCD *(Parent unit only):*
- The LCD is used in our design for an output device to display location information of each child.
- It receives its inputs from port B (pins 34 - 40) of the parent PIC16F877. Pin 33 of port B on the parent PIC is not used for the LCD.
- The LCD is initialized, programmed and controlled using a 4-bit data bus instead of the 8-bit data bus that can alternately be used.
- The LCD is initialized after the voltage to the display has risen above 4.5V using software. The initialization takes place after the GPS's have been given their time to acquire coordinates. This initialization sequence can be seen on the display by the screen turning blank.
- The programming for the LCD is done to store characters into the CG RAM (Character Generated Random Access Memory) that we needed to display that were not already programmed into the display.
- The controlling of the LCD is just basically putting everything that the parent (distance and direction) has gathered from the child(ren) onto the screen for the parent to use to track their child(ren).

DIGITAL COMPASS 1490*(Parent only): The digital compass tells the direction the parent is facing using a 4 bit output.*
- The digital compass is made by Densmore and is capable of detecting 8 different directions.

- The compass can accept input voltages from 5 – 12 volts. The design specified in the following schematics use a 5 volt source.
- The compass uses the magnetic field created by the earth to determine position.
- There is a transistor for each major direction (N,S,E,W). If the compass is directed in one of the following directions, the appropriate output pin sends a corresponding low voltage output.
- The device is connected to port A of the parent device and has pull up resistors to keep voltage levels at 5 volts.
- 1K resistors are used to limit the amount of current into the PIC16F877 and the compass.

Complete Circuit Schematics

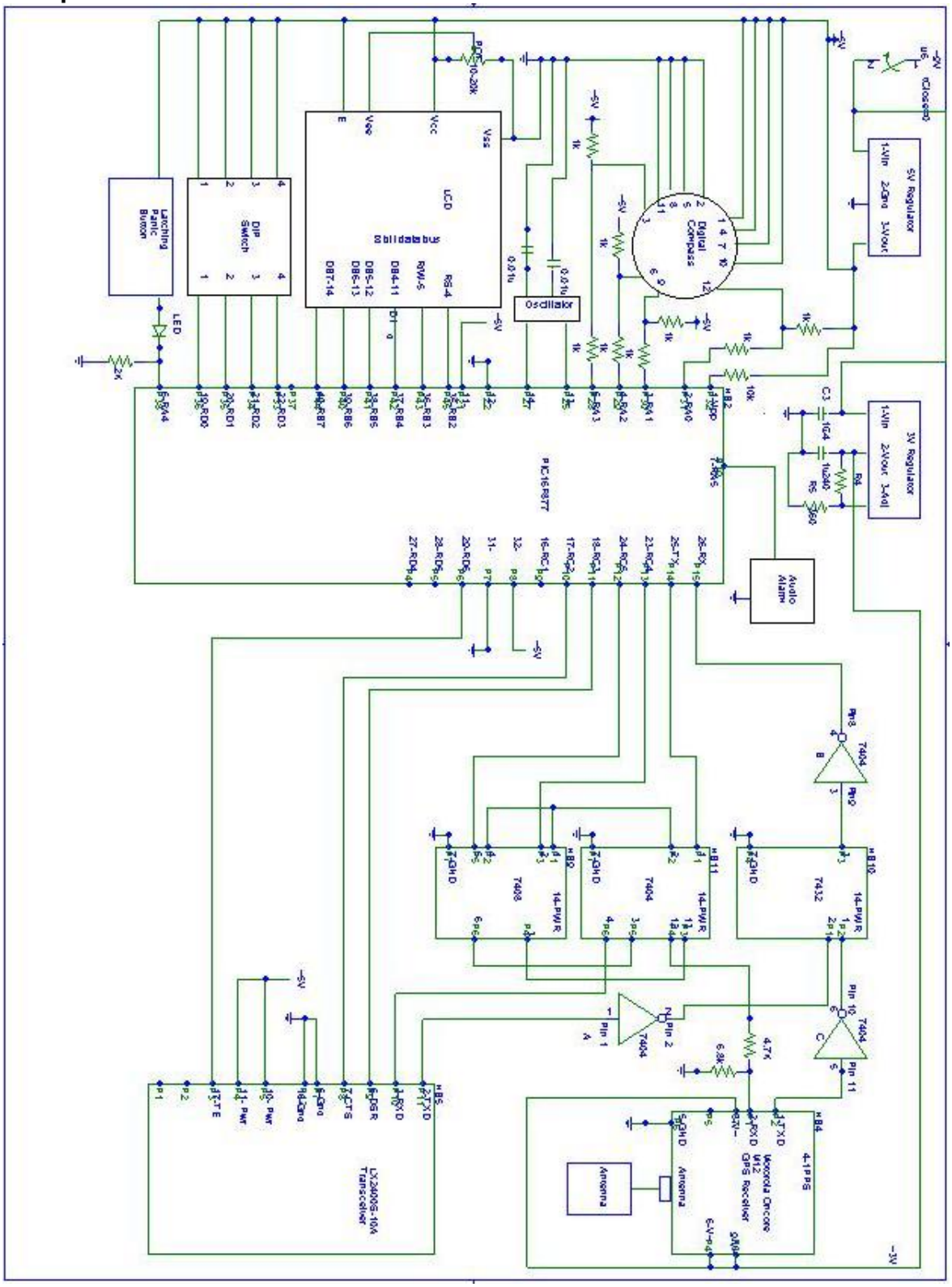


Figure 3 – Parent Schematic

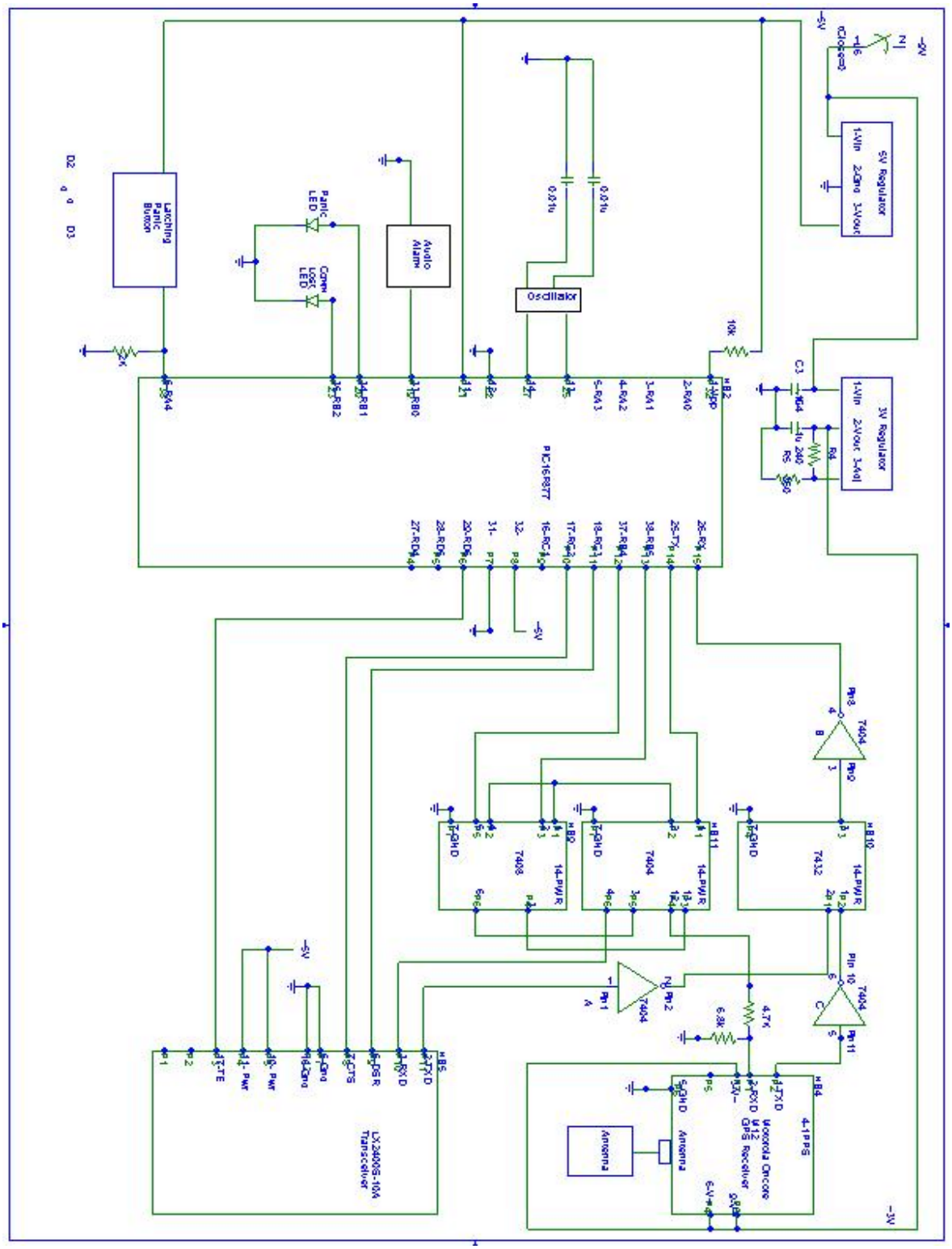


Figure 4 – Child Schematic

Circuit Board Layouts

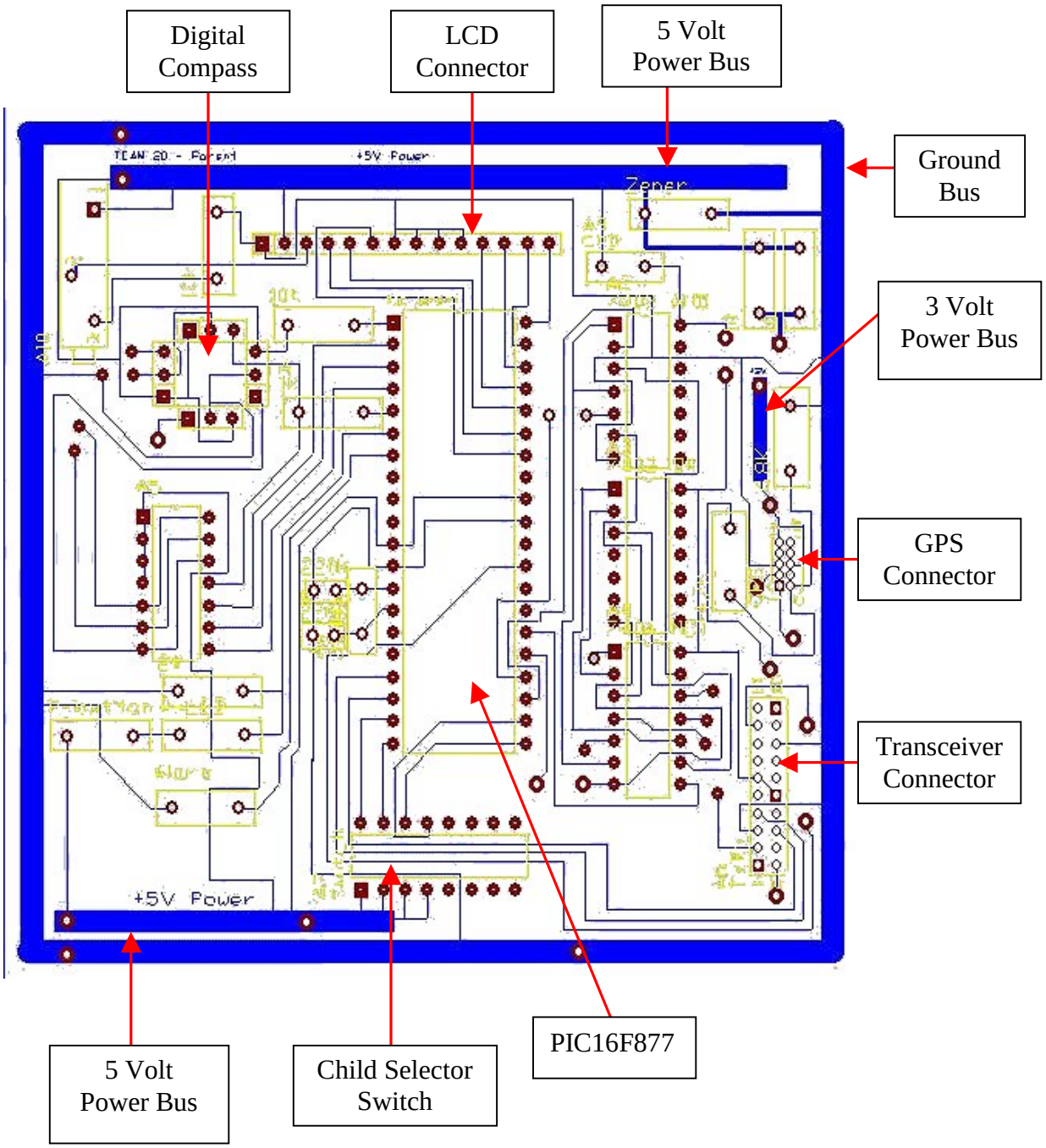


Figure 5 – Parent PCB Layout

SOFTWARE DESCRIPTION

Parent Device

The flow chart below describes the software on the parent PIC16F877. Each block will be broken down in the following explanation.

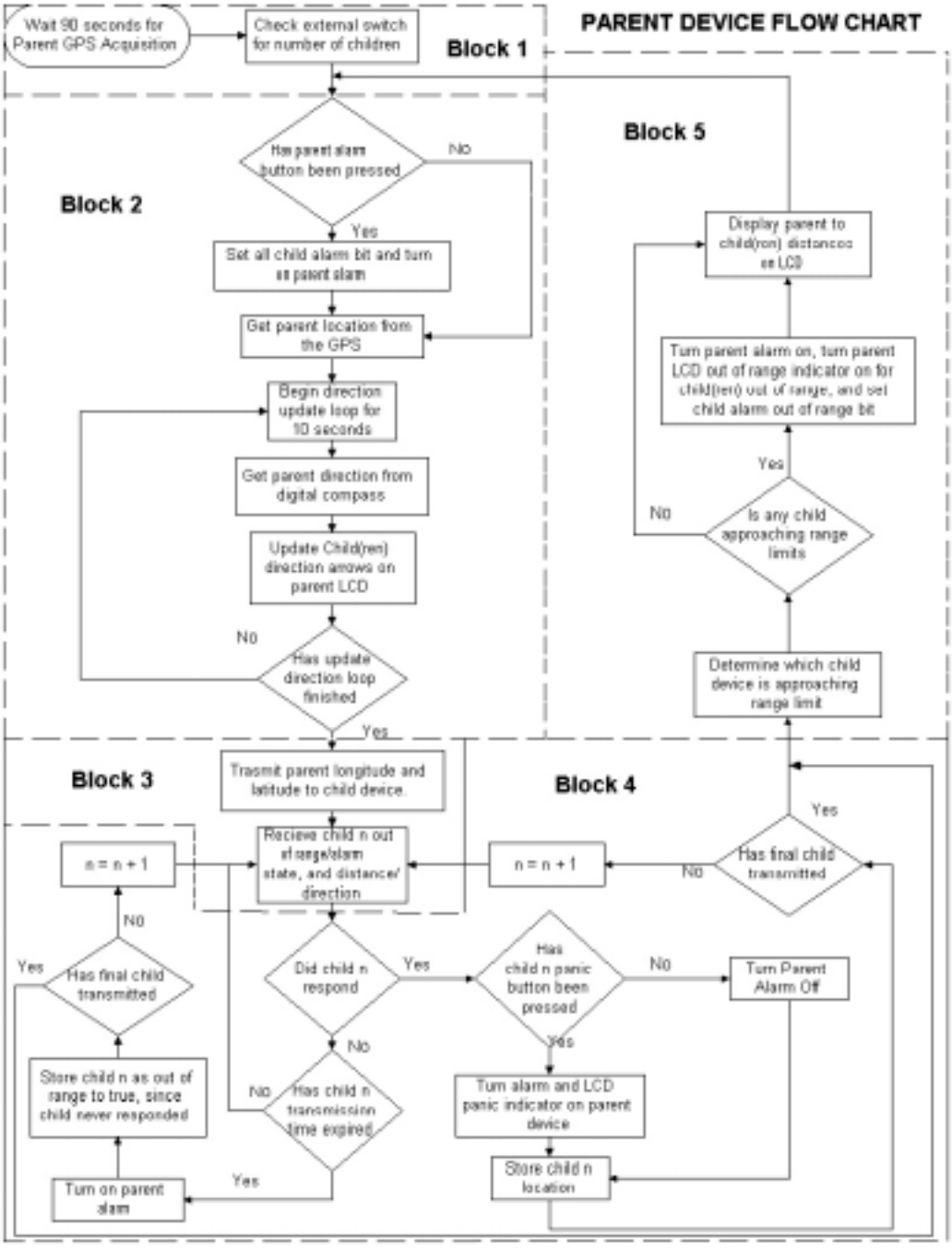

PARENT DEVICE FLOW CHART
Block 1
Block 2
Block 3
Block 4
Block 5
Wait 90 seconds for Parent GPS Acquisition
Check external switch for number of children
Has parent alarm button been pressed
No
Yes
Set all child alarm bit and turn on parent alarm
Get parent location from the GPS
Begin direction update loop for 10 seconds
Get parent direction from digital compass
Update Child(ren) direction arrows on parent LCD
No
Has update direction loop finished
Yes
Trasmit parent longitude and latitude to child device
Recieve child n out of range/alarm state, and distance/ direction
n = n + 1
No
Has final child transmitted
Yes
Did child n respond
Yes
Has child n panic button been pressed
No
Turn Parent Alarm Off
Yes
Turn alarm and LCD panic indicator on parent device
Store child n location
No
Has child n transmissinn time expired
No
Yes
Store child n as out of range to true, since child never responded
Turn on parent alarm
n = n + 1
No
Has final child transmitted
Yes
Determine which child device is approaching range limit
Is any child approaching range limits
No
Yes
Turn parent alarm on, turn parent LCD out of range indicator on for child(ren) out of range, and set child alarm out of range bit
Display parent to child(ren) distances on LCD

Figure 6 – Parent Flow Chart

Block 1: Getting ready for operation

- The GPS requires up to 90 seconds to acquire enough satellites to determine the parent device's location.
- The PIC16F877 checks to see how many children are present by checking which dipswitches are moved to the on position.

Block 2: Getting ready for transmission to child device

- The PIC16F877 checks to see if the parent alarm has been pressed and stores the status of the alarm button
- The PIC16F877 sends a request to the GPS for the current position of the parent device. The longitude and latitude given by the GPS is then stored. The GPS and PIC16F877communication can be watched by monitoring the USART transmit pin (PIN 25), and the USART receive pin (PIN 26) on the PIC16F877. Refer to *Appendix A* for the request sent to the GPS and a typical response received from the GPS.
- The PIC16F877 then checks PINS 2-5 (A0-A3) to get the current heading of the parent from the digital compass. *Appendix B* shows what the digital compass should output given its orientation.
- The PIC16F877 then updates the LCD with the parent device's relative direction to the child devices.
- The parent device is designed to update the direction to each child on the LCD every 20 milliseconds. However every 10 seconds the child's distance from parent to child is updated, during this maneuver the direction to each child isn't updated until the parent device is finished updating the LCD with the new distance. This operation takes less than a second, but during this time the direction isn't updated.

Block 3: Transmitting to child devices and receiving from child devices

- The longitude and latitude received from the parent GPS and the alarm status are transmitted to the child device using the spread spectrum transceiver. The PIC16F877 and transceiver communication can be watched by monitoring the USART transmit pin (PIN____) on the PIC16F877. Refer to *Appendix C* for a typical transmission sent to the child device. (NOTE: A transmission may be repeated several times in order to compensate for the frequency hopping of the transceivers, so this may happen more than once.)
- After transmitting the information the parent device enters a receive mode in which it waits to receive the distance and direction back from the child device. The PIC16F877and the transceiver communication can be watched by monitoring the USART receive pin (PIN 26) on the PIC16F877. Refer to *Appendix C* for a typical transmission received from the child device.

- Block 3 can be repeated up to 4 times, depending on the number of child devices present.

Block 4: Checking and storing information received from the child device

- Occasionally the child device may not respond. This either means there is a problem with the child device, but more likely the child device has gone beyond the 0.5 mile range of the parent device. If this even occurs the parent device will assume the child is out of range.
- If the child device sends a transmission back to the parent device, the transmission goes through a series of checks.
    - Checks child device's panic state.
    - Checks child device's distance from parent

    Refer to *Appendix C* to see the transmission received from the child and what is checked to know the state of the child.

Block 5: Updating LCD and alarms

- The parent device alarm is turned on if any child device is out of range, or child device panic button has been pressed.
- The parent device LCD is updated with the child device's new out of range and panic information.

Child Device

The flow chart below describes the software on the child PIC16F877.

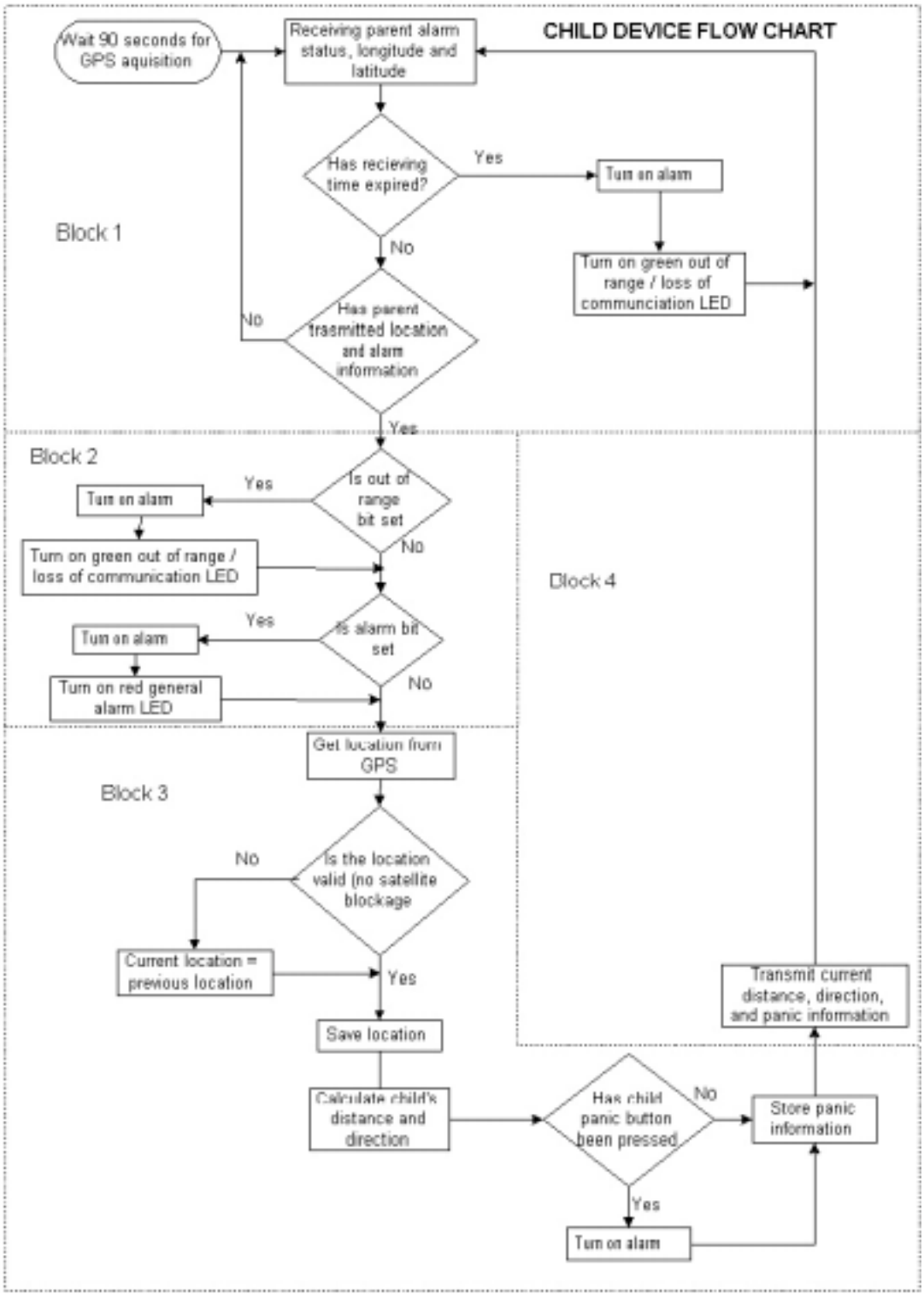


Figure 7 – Child Block Diagram

Block 1: Waiting for GPS acquisition and parent information

- The PIC16F877 waits 90 seconds for the GPS to acquires satellites and determine the child device's longitude and latitude coordinates. The GPS and PIC16F877communication can be watched by monitoring the USART transmit pin (PIN 25), and the USART receive pin (PIN 26) on the PIC16F877. Refer to *Appendix A* for the request sent to the GPS and a typical response received from the GPS.
- The PIC16F877 enters a receive mode, until it receives the parent devices location and alarm status or times out. If the child devices times out this means the parent device didn't send a transmission. The PIC16F877and the transceiver communication can be watched by monitoring the USART receive pin (PIN 26) on the PIC16F877. Refer to *Appendix C* for a typical transmission received from the child device.

Block 2: Process and store the information received from the parent device

- The parent's transmission to the child includes the child's out of range and the parent's alarm information. According to the transmission received by the child device the appropriate LED's and the alarm is turn on.

Block 3:

- Now that the parent location and the child location is known, the distance and direction from parent to child is calculated for transmission back to the parent device.

Block 4:

- Now that the distance and direction of from the parent is located, it is transmitted back to the parent. The transceiver and PIC16F877 communication can be watched by monitoring the USART transmit pin (PIN 25) on the PIC16F877. Refer to *Appendix C* for a typical transmission received from the child device.

SUBSYSTEM BREAKDOWN

The Microchip processor is responsible for controlling each device. If the parent or child device would fail to operate, the problem may be found by checking one of the following subsystems. Below is a listed of expected outputs from each device including possible reasons for error.

** The pinouts for many many of the devices are included in the text and in appendices. It may be helpful in troubleshooting to download the specifications for each device from the manufactures homepage.*

Power Circuit

Refer to the schematic of the power circuit located in the schematics in *Figure 2 and Figure 3* on pages 11 and 12. The circuit can be found on the perforated circuit board within the parent and child units. With fully charged batteries there should, the power circuit should always output 4.85-5.15 volts and 2.85-3.15 to the respective power bus. To verify this, check that there is 3 volts at the output of pin 3 of the 3V voltage regulator and 5 volts at the output pin 3 of the 5V voltage regulator. If the appropriate voltage levels are found, the regulators are working properly. Also check the power busses located on the parent/child device to ensure proper voltage readings. If an unexpected voltage level is found, check all connections within the power circuit and the parent/child main circuit board.

PIC16F877

As previously mentioned, the PIC16F877 controls all input and output devices. A good indication that the PIC may be malfunctioning is if the LCD never initializes. The fist place to check is the power circuit. Make sure appropriate voltages are on the power busses. Next, check to see if pin 1 and pin 11 have 5 volts. Next, check all grounds to the PIC. Refer to the schematics to find which pins are tied to ground. Another possible problem may be the oscillator. Using an oscilliscope, the oscillator can be tested for the right frequency output. If all this seems to be operating correctly, the PIC may need to be replaced. Replace the PIC with another PIC with the same specifications and the respective .hex file generated from MPLAB – C.

Transceiver

To ensure that the transceivers are communicating properly, first monitor pin 20 of the transceiver in the child device. After startup, the pin should at first be logic level high and after approximately 7-15 seconds the pin should go low. If pin 20 never goes low, the transceivers may have been switched, and the process should be repeated on the transceiver in the parent device. If pin 20 of the transceiver in the parent device goes low,

switch the transceivers and the system should function properly. If neither pin 20 of the transceiver in the parent device or the child device goes low, then proceed with the following tests. First, check the amount of current that the parent and child devices are sinking. Each device should sink approximately 230mA. If either of the devices is sinking less than 230mA of current, check continuity between the transceiver and the 5V bus. If either of the devices is sinking considerably more than 230mA, the transceiver is not functioning correctly and the manufacturer should be contacted. If the devices are sinking the correct amount of current, the EEPROM on one or both of the transceivers could be corrupted.

GPS

If the LCD starts initialization but returns a blank screen, then it is a good indication the parent GPS is not responding.

It is more difficult to determine if the child GPS quits responding. If the child GPS quits responding, the parent will "timeout" and an alarm will sound. This will also happen if the transceiver quits working and if the child device is not turned on. The best way is to test that the child device is turned on and the child transceiver is functioning properly. Once this is confirmed, step throught the following GPS checkpoints.

Appendix H has a complete list of GPS pinouts.

- Check the power buses for the appropriate busses. Refer to the power circuit troubleshooting area if there are unexpected voltage levels.
- Check to see if the appropriate pins are receiving the specified voltage levels.
- If so, it is now time to construct the RS232 circuit in *Appendix D.*
- Make sure the TTL output pin is stepped down from 5 volts to 3 volts before connecting to the GPS RX pin.
- Connect the GPS TX pin to the TTL receive pin on the MAX232CPE chip.
- Open a serial monitoring program on computer. Send the following hex statement, 40407100340D0A, to the GPS and monitor the response in ASCII. The response should follow the response in *Appendix A.*

Refer to the Motorola webpage for the M12 GPS receiver if the problem persists.

Compass

The digital compass is designed to use a 4 bit bus to determine the direction the parent is facing. An indication that the compass has been damaged or is not working correctly is if the parent device arrow is changing but not pointing in the direction of the child. The compass can be easily taken out of the circuit and tested. *Appendix B* has the pinouts for the digital compass. Connect the ground and the power pins as shown. Use resistors to limit the current under 20 mA to the digital compass data pins (pin 3 on each side of the compass). Connect the

LEDs to a 5 Volt source and move the compass in all directions. The LEDs will light up when they the data pin goes low and sinks the current. If the devices fails to light LEDs or lights up the LEDs in a haphazard manner, then the compass made need replacement.

LCD

There are two possible problems that could occur with the LCD. The LCD just may not turn on, or the LCD may be display unusual or foreign characters to the screen. If one of these situations occurs, perform one of the following tasks:

- If the LCD quits working there are two possible solutions that should be tried.
- First, adjust the potentiometer located on the power circuit board. If you still see nothing on the screen try the next step.
- Carefully remove the ribbon cable from the parent PCB board. Build a test circuit as seen below in *Figure 8*. Adjust the potentiometer, and if you still see nothing, the LCD is probably broken and will need to be replaced. If you do see the black squares on the screen on lines 1 and

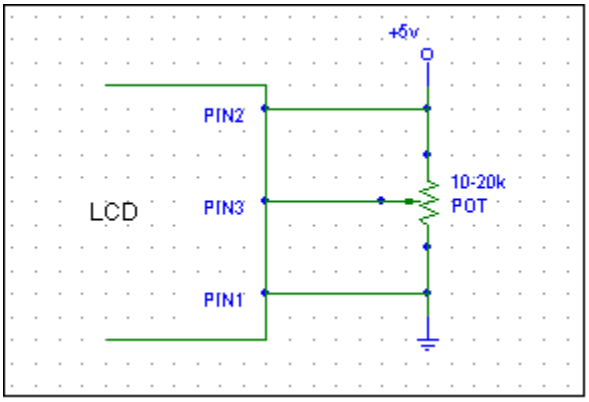


Figure 8 – LCD Potentiometer circuit

3 then the LCD is working properly and only the potentiometer will need to be replaced. When inserting the LCD back onto the parent PCB, be careful and makes sure that PIN 1 on the LCD is connected to PIN 1 on the board. The brown wire on the ribbon cable and the leftmost PIN on the board are PIN 1 on both the LCD and the board.

- If the LCD just starts displaying some unusual or foreign characters to the screen, the devices just simply need to be restarted. If the problem continues make sure that the LCD is plugged tightly onto the parent board and check the PIC16F877 troubleshooting section.

Bus Switch System

The only foreseen problem with the bus switch system is the failure of one of the three logic chips used to form the switch or a broken connection. In order to test this system, a Maxim232 RS232 chip and the serial port of a computer with appropriate software must be used to probe the circuit. First, connect the RS232 chip to a serial port of a computer and open any software program that will allow the data to be viewed in hexadecimal values. Next, place the probe on pin 25 of the PIC16F877 and turn on the system. After 90 seconds, a request to the GPS receiver should appear followed by a transmission to the transceiver. If both requests appear repeatedly, then the bus switch is functioning correctly. If the requests never appear, be sure that the correct pin is being probed. If the requests appear only once, then the receive pins of both the transceiver and the GPS receiver need to be probed (refer to Fig. ???? to locate the correct pins). If the data is not being received by either or both of the devices, then trace the continuity through the bus switch by using Fig. ????. If there is no discontinuity, then test each chip for power and ground (located on pins 7 and 14 of each logic chip). If all chips in the switch have power and ground and there are no discontinuities, then one or more of the chips must not be functioning correctly. Replace each chip noting that the 7404 "NOT" chip needs to be replace by a chip that interfaces with the GPS receiver's 3V logic levels.

Appendix A: Position request sent to GPS and corresponding response

GPS location request:

ASCII - @@EqmC<CR><LF>

GPS response:

ASCII - @@Eq,mm,dd,yy,hh,mm,ss,dd,mm.mmmm,n,ddd,mm.mmmm,w,
shhhh.h,sss.s,hh.h,m,t,dd.d,nn,rrrr,aa,CCC<CR><LF>

(The parent device is only concerned with the current longitude and latitude all other information can be disregarded.)

Date

mm	month	01..12
dd	day	01..31
yy	year	99..19

UTC Time

hh	hours	00..23
mm	minutes	00..59
ss	seconds	00..60

Latitude

dd	degrees	00.99
mm.mmmm	minutes	00.59.9999
n	direction	N=North, S=South

Longitude

ddd	degrees	000..180
mm.mmm	minutes	00.59.9999
w	direction	W=West, E=East

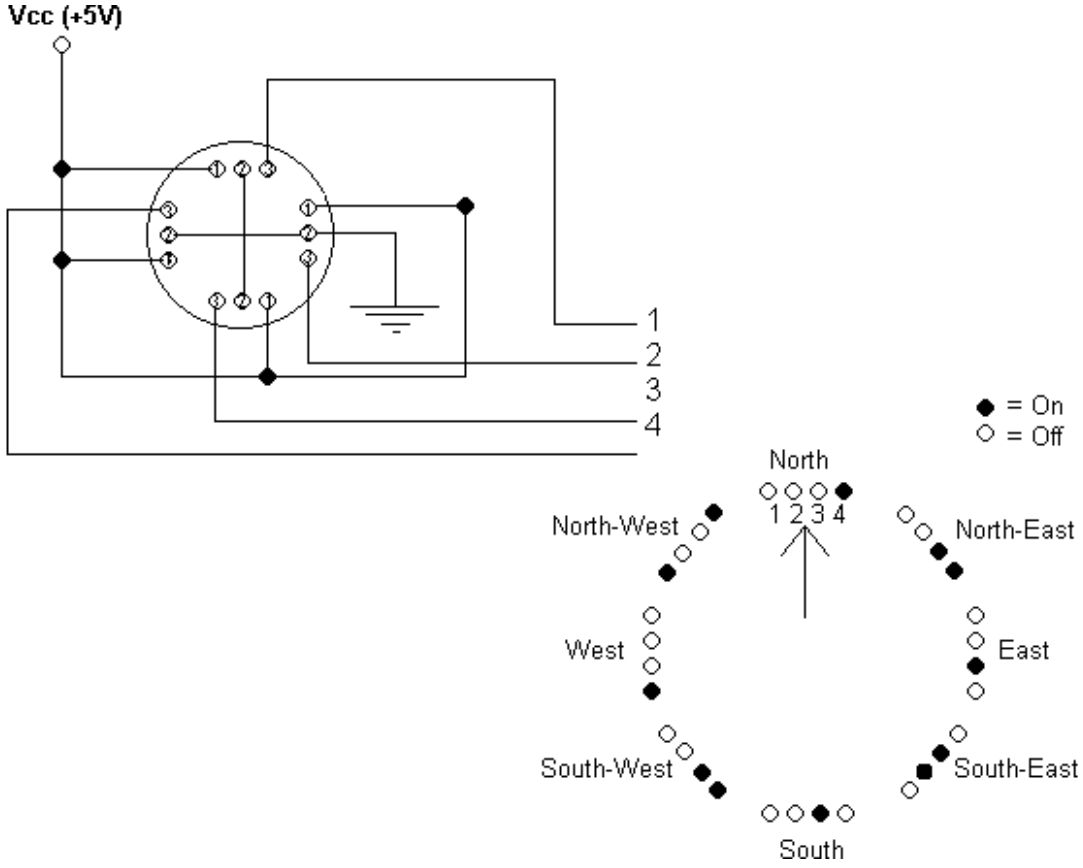
Velocity

sss.s	speed in knots	000.0..999.9
hhh.h	heading in degrees	000.0..359.9

Reciever status

m	fix mode	0 = autonomous
		1 = differential
t	fix type	0 = no fix
		1 = 2D fix
		2 = 3d fix
		3 = propagate mode
dd.d	dilution of preciesion(DOP)	00.0..99.9
nn	number of satellites in use	00..37
rrrr	reference station ID	0000..1023
aa	age of differential data in s	00..60
CCC	checksum	000..255

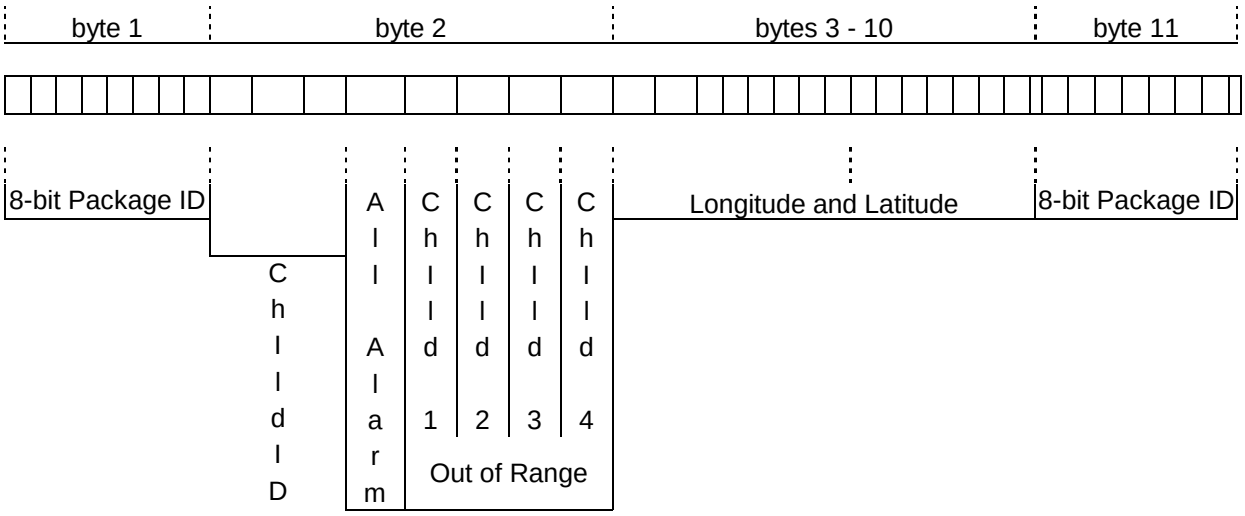
Appendix B – Digital compass directions and PIN data



Refer to the *Figure 3* for more information on how the digital compass is wired to the PIC16F778.

Appendix C: The transmission sent to the child device and transmission received from child device.

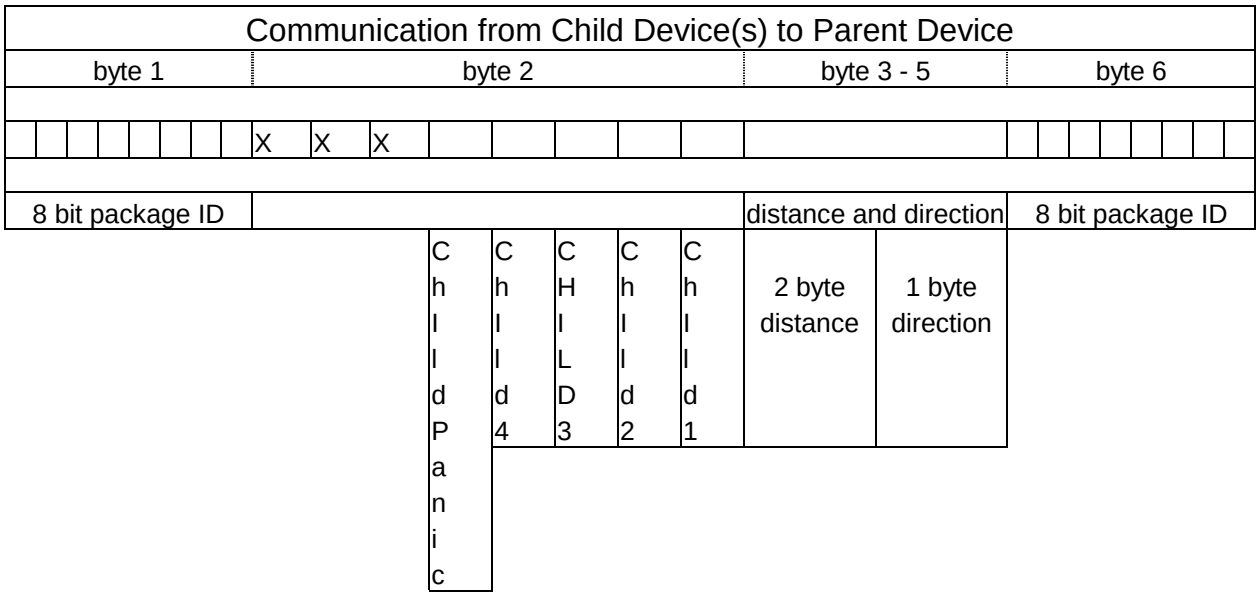
Communication from Parent to Child Device(s)



Child Alarm Control

0	0	0	-	C	h	I	L	d	1
0	0	1	-	C	h	I	L	d	2
0	1	0	-	C	h	I	L	d	3
1	0	0	-	C	h	I	L	d	4

Example: (Hexadecimal) 7300XXXXXXXXXXXXXXXX37 (X's depend on location)

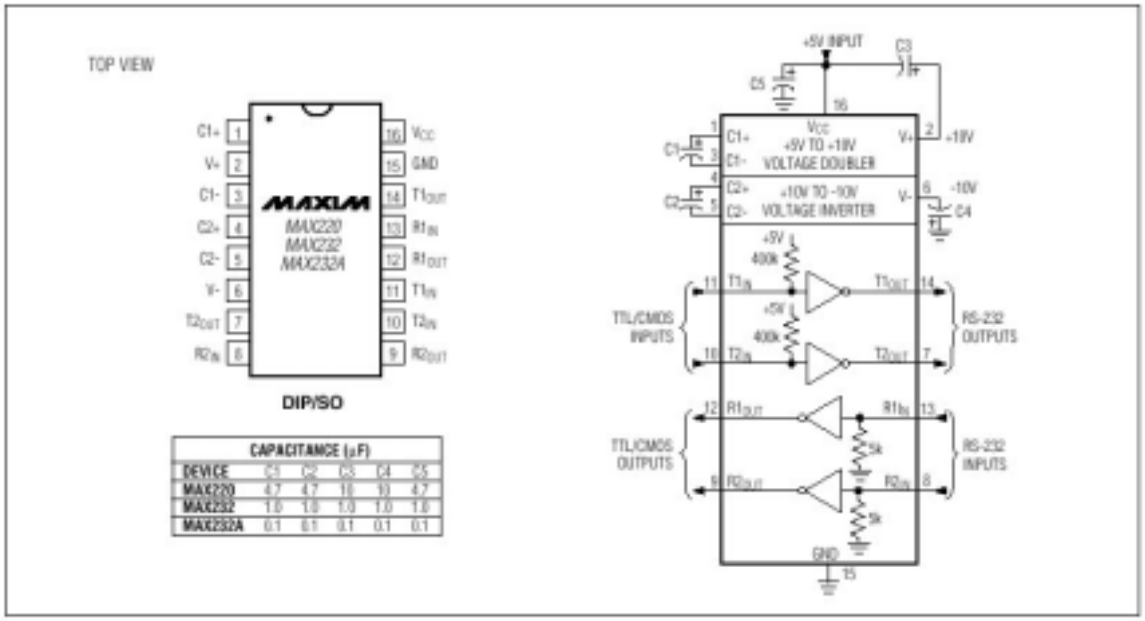


Example: (Hexadecimal) 730145622137

Appendix D: Wiring Diagram for RS232 Communication

+5V-Powered, Multichannel RS-232 Drivers/Receivers

MAX220–MAX249



Appendix E: Complete Child Software

```
#device pic16f877

#include <math.h>
#include <stdlib.h>
#include <16F877.H>
#include "trans.h"
#include "serial.h"

#define CHILD_NUMBER 1

#define pi 3.14159

#fuses HS,NOWDT,NOPROTECT


struct child_struct
{
      float theta;
      float latitude;
      float longitude;
      long int distance;
      char direction;
}child;

struct parent_struct
{
      float latitude;
      float longitude;
}parent;

struct output_struct
{
      char package_id;
      char panic_and_child_id;
      long int distance;
      char direction;
      //float theta;
      char package_id_2;
}output;

struct input_struct
{
      char package_id;
      char panic_and_child_id;
      float latitude;
      float longitude;
      char package_id_2;
}* input_packet;

void get_cposition();
void calc_distance(void);
void calc_direction(void);
void calc_theta(void);
```

```
float c_lat, c_lon;

main()
{
      char input_data[12];
      long int error,i;
      char *data;
      char data2[9];


      output_low(PIN_B0);
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(19000);
      //delay_ms(9000);
      receive(input_data,12);
      receive(input_data,12);
      output.panic_and_child_id=0x00;
      //output.distance=0;
      //output.direction=0x00;

      output_low(PIN_B0);
      output_low(PIN_B1);
      output_low(PIN_B3);

      while(TRUE)
      {
            //output_low(PIN_B4);
            //output_low(PIN_B5);
            //for(i=0;i<10000;i++)  //loop for ~10 seconds
            //{
            //    if(kbhit()==0)
            //    {
            //          delay_ms(1);
            //    }
            //    else
            //    {
                  error=transceiver_receive(input_data,11);
                  input_packet=(struct input_struct *)input_data;

                  if(error==11 && input_packet->package_id==0x73 &&
input_packet->package_id_2==0x37)
                  {
                        if(bit_test(input_packet-
>panic_and_child_id,7)==0)
                        {
                              if(bit_test(input_packet-
>panic_and_child_id,6)==0)
                              {
                                    if(bit_test(input_packet-
>panic_and_child_id,5)==0)
```

```
                                    {
                                          /* exit loop if polling this
child */
                                          i=10000;
                                          //break;
                                    }
                              }
                        }
                  }

                  /* get panic button state --> updates panic LED */
                  if((input(PIN_B3)==1) || (bit_test(input_packet-
>panic_and_child_id,4)==1))
                  {
                        /* set panic bit */
                        bit_set(output.panic_and_child_id,7);

                        /* turn on panic LED */
                        output_high(PIN_B1);

                        /* turn on audio alarm */
                        output_high(PIN_B0);
                  }
                  else
                  {
                        /* set panic bit to 0 */
                        bit_clear(output.panic_and_child_id,7);

                        /* turn panic LED off */
                        output_low(PIN_B1);

                        /* turn off audio alarm */
                        output_low(PIN_B0);
                  }
            //    }
            //}

            if(error==11 && input_packet->package_id==0x73 &&
input_packet->package_id_2==0x37 && (bit_test(input_packet-
>panic_and_child_id,7)==0) && (bit_test(input_packet-
>panic_and_child_id,6)==0) && (bit_test(input_packet-
>panic_and_child_id,5)==0))
            {
                  /* wait 50ms x (child#-1) */

                  if(CHILD_NUMBER==1)
                        error=bit_test(input_packet-
>panic_and_child_id,3);
                  else if(CHILD_NUMBER==2)
                        error=bit_test(input_packet-
>panic_and_child_id,2);
                  else if(CHILD_NUMBER==3)
                        error=bit_test(input_packet-
>panic_and_child_id,1);
                  else if(CHILD_NUMBER==4)
                        error=bit_test(input_packet-
>panic_and_child_id,0);
```

```
if((error==1)/* || (input(PIN_B3)==1)*/)
{
      /* turn on alarm */
      output_high(PIN_B0);

      /* turn on green gereral alarm LED */
      output_high(PIN_B2);
}
else if(error==0)
{
      /* turn off alarm */
      output_low(PIN_B0);

      /* turn green gereral alarm LED off */
      output_low(PIN_B2);
}

/* get panic data */
error=bit_test(input_packet->panic_and_child_id,4);
if((error==1) || (input(PIN_B3)==1))
{
      output_high(PIN_B0);
      output_high(PIN_B1);
}
else
{
      output_low(PIN_B0);
      output_low(PIN_B1);
}

/* get location from GPS */
//Bus Switch code
//delay_ms(1000);
output_low(PIN_B4);
output_high(PIN_B5);
get_cposition();


/* is location valid */
/* if not valid current_loction=previous_location */

/* if valid save current_location */

/*  get distance and direction */
//child.longitude = 39.6334;//~30ft
//child.latitude = 79.9639;
//parent.latitude = 39.6333;
//parent.longitude = 79.9639;
parent.latitude=input_packet->latitude;
parent.longitude=input_packet->longitude;
calc_distance();
calc_theta();
calc_direction();

/* get panic button state */
if(input(PIN_B3)==1)
```

```
	{
		/* set panic bit */
		bit_set(output.panic_and_child_id,7);

		/* turn on panic LED */
		output_high(PIN_B1);
	}
	else
	{
		/* set panic bit to 0 */
		bit_clear(output.panic_and_child_id,7);

		/* turn panic LED off */
		output_low(PIN_B1);
	}

	/* initialize output packet */
	output.package_id=0x73;
	output.package_id_2=0x37;
	output.distance=child.distance;
	output.direction=child.direction;
	//output.theta=child.theta;
	//output.distance=100;
	//output.theta=99.99;
	//output.direction=0x00;;
	if(CHILD_NUMBER==1)
	{
		bit_clear(output.panic_and_child_id,5);
		bit_clear(output.panic_and_child_id,6);
	}
	else if(CHILD_NUMBER==2)
	{
		bit_set(output.panic_and_child_id,5);
		bit_clear(output.panic_and_child_id,6);
	}
	else if(CHILD_NUMBER==3)
	{
		bit_clear(output.panic_and_child_id,5);
		bit_set(output.panic_and_child_id,6);
	}
	else if(CHILD_NUMBER==4)
	{
		bit_set(output.panic_and_child_id,5);
		bit_set(output.panic_and_child_id,6);
	}

	/* transmit output packet */
	//output.distance=100;
	//output.direction='N';
	output_low(PIN_B5);
	output_high(PIN_B4);
	data=&output;
	transceiver_transmit(data,6);

}
else
{
```

```
                  /* turn on alarm */
                  output_high(PIN_B0);

                  /* turn on green out of range LED */
                  output_high(PIN_B2);
            }
      }
}

/************************************************************************
************************************************/

/***************************************/
/*  transmits first n characters of the */
/*  output array where n=length        */
/***************************************/
void transmit(char output[20], int length)
{
   int i=0;

   for(i=0;i<length;i++)
   {
      putc(output[i]);
   }
}


/***************************************/
/* receives n characters and stores    */
/* them in the first n elements of the */
/* input array where n=length and is   */
/* NOT equal to 0.  If lenght=0, it    */
/* continues to get characters data    */
/* it receives a carriage return       */
/***************************************/
int receive(char input[20], int length)
{
   char data='a';
   long int timeout=0;
   int i=0;
   int kbhit=0;

   //timeout=0;
   //if(length==0)
   //{
   //  while(data != 0x0D)
   //  {
   //     kbhit=kbhit();
//
           /* wait max of 20 ms */
//         while((kbhit==0)&&(++timeout<2000))
//         {
//               delay_us(10);
//               kbhit=kbhit();
//         }

//         if(timeout>=2000)
```

```
//                return 0;

//          if(kbhit)
//          {
//                data=getc();
//                input[i] = data;
//                i++;
//          }
//          else
//        {
//                return i;
//        }
//    }
//   }
//   else
//   {

//          input[0]=0x00;
//          input[1]=0x0B;
//          input[2]=0x73;
//          input[3]=0x10;
//          input[4]=0x00;
//          input[5]=0x00;
//          input[6]=0x00;
//          input[7]=0x00;
//          input[8]=0x00;
//          input[9]=0x00;
//          input[10]=0x00;
//          input[11]=0x00;
//          input[12]=0x37;
//          return 13;
            while(i<length)
            {

                  timeout=0;
                  kbhit=kbhit();

                  /* wait max of 20 ms */
                  while((kbhit==0)&&(++timeout<2000))
                  {
                        delay_us(10);
                        kbhit=kbhit();
                  }
                  if(kbhit)
                  {
                        data=getc();
                        input[i] = data;
                        i++;
                  }
                  else
                  {
                        return i;
                  }
            }
//   }

   return i;
```

```
}

/************************************************/
/*                                      */
/*  transceiver transmit                        */
/*                                      */
/************************************************/
void transceiver_transmit(char data[20], int length)
{
      char output[20];

      output[0]=PREAMBLE;
      output[1]=PREAMBLE;
      output[2]=PREAMBLE;
      output[3]=SYNC;
      output[4]=0x00;
      output[5]=(char)length;

      //BUS SWITCH CODE
      output_high(PIN_B4);
      output_low(PIN_B5);


      //make sure the transceiver is not in hopping state
      while(input(DSR)!=1)
      {
            delay_us(10);
      }

      output_low(TE);
      while(input(CTS)!=0)
      {
            delay_ms(1);
      }

      transmit(output,6);
      transmit(data,length);

      output_high(TE);
      while(input(CTS)!=1)
      {
            delay_us(10);
      }

      //if the transceiver has hopped while transmitting repeat
transmission
      //if(input(DSR)==0)
      //{
            //clear latch

            //transceiver_transmit(data,length);
      //}
}


/************************************************/
```

```
/*
*/
/*  transceiver receive                              */
/*
*/
/************************************************/
int transceiver_receive(char data[20],int length)
{
      long int len,i;
      char receive_data[20];


      //BUS SWITCH CODE

      /* receive length+2 bytes -> accounts for lenght high and low
bytes from transceiver */
      for(i=0;i<10000;i++)
      {
            if(kbhit() == 1)
            {
                  break;
            }

            delay_ms(1);
      }
      if(i<10000)
      {
      len=receive(receive_data,length+2);

      /* strip the length_high and length_low bytes off of transmission
*/
      for(i=0;i<len-2;i++)
      {
            data[i]=receive_data[i+2];
      }

            return (int)receive_data[1];
      }
      else
      {
            return 0;
      }

}


/************************************************/
/*
*/
/*  get position                                    */
/*
*/
/************************************************/
void get_cposition()
{
   char output[8];
   char input[27];
```

```
   char crap;
   long int i=0;
   int data_length=0;
   float temp;
   float latitude = 2.55;
   float longitude = 6.66;

   //delay_ms(2000);
   output[0]=0x40;  // @
   output[1]=0x40;  // @
   output[2]=0x45;  // E
   output[3]=0x71;  // q
   output[4]=0x00;  // 0 for the mode of output(once)
   output[5]=0x34;  // Checksum for (Eq0)
   output[6]=0x0D;  // Carriage Return
   output[7]=0x0A;  // Line Feed

   data_length=receive(input,27);
   transmit(output,8);

   while(kbhit()==0)
   {
      delay_us(10);
   }

   data_length=receive(input,23);
   data_length=receive(input,27);

/* Conversion of the input[0-9] into floating point latitude  */

   latitude = (((int)input[0]-48)*10) + ((int)input[1]-48);
   temp = ((((int)input[3]-48) * 10) + ((int)input[4]-48));
   temp = temp + ((((int)input[6]-48)*.1) +(((int)input[7]-48)*.01));
   temp = temp + ((((int)input[8]-48)*.001) + (((int)input[9]-
48)*.0001));
   temp = temp/60;
   latitude = latitude + temp;
   child.latitude = latitude;

/* Conversion of the input[13-26] into floating point longitude  */

   longitude = (((int)input[13]-48)*100);
   longitude = longitude + (((int)input[14]-48)*10) + ((int)input[15]-
48);
   temp = ((((int)input[17]-48) * 10) + ((int)input[18]-48));
   temp = temp + ((((int)input[20]-48)/10) +(((int)input[21]-48)/100));
   temp = temp + ((((int)input[22]-48)/1000) + (((int)input[23]-
48)/10000));
   temp = temp/60;
   longitude = longitude + temp;
   child.longitude = longitude;

   if ((longitude == 0) && (latitude ==0))
   {
      output_high(PIN_B2);
   }
   data_length=receive(input,26);
```

```
   data_length=receive(input,23);


}


/*****************************************/
/* temp distance and direction           */
/*****************************************/
void calc_theta()
{
      float c_lat, c_lon;
      float int_c_lon, int_c_lat;
      c_lat = child.latitude - parent.latitude;
      c_lon = child.longitude - parent.longitude;

      //int_c_lon=(long int)ceil(c_lon);
      //int_c_lat=(long int)ceil(c_lat);
      int_c_lon = c_lon;
      int_c_lat = c_lat;


      if(int_c_lat == 0.0 && int_c_lon == 0.0)
            child.theta = 90.0;
      else if(int_c_lat == 0.0 && int_c_lon < 0.0)
            child.theta = 0.0;
      else if(int_c_lat == 0.0 && int_c_lon > 0.0)
            child.theta = 180.0;
      else if(int_c_lon == 0.0 && int_c_lat < 0.0)
            child.theta = 270.0;
      else if(int_c_lon == 0.0 && int_c_lat > 0.0)
            child.theta = 90.0;
      else
      {
            child.theta = atan(c_lat / c_lon);
            child.theta = child.theta*180.0/3.1415926535898;

            if(int_c_lat > 0.0 && int_c_lon < 0.0)
                  child.theta = -(child.theta);
            else if(int_c_lat < 0.0 && int_c_lon > 0.0)
                  child.theta = 180.0 - child.theta;
            else if(int_c_lat < 0.0 && int_c_lon < 0.0)
                  child.theta = 360.0 - child.theta;
            else
                  child.theta = 180.0 - child.theta;
      }
}

void calc_direction(void)
{

      if((child.theta > 337.5 && child.theta <= 360.0) || (child.theta
>=0 && child.theta <= 22.5))
            child.direction = 'E';
      else if(child.theta > 22.5 && child.theta <= 67.5)
            child.direction = 'P';
      else if(child.theta > 67.5 && child.theta <= 112.5)
```

```
            child.direction = 'N';
      else if(child.theta > 112.5 && child.theta <= 157.5)
            child.direction = 'Q';
      else if(child.theta > 157.5 && child.theta <= 202.5)
            child.direction = 'W';
      else if(child.theta > 202.5 && child.theta <= 247.5)
            child.direction = 'Z';
      else if(child.theta > 247.5 && child.theta <= 292.5)
            child.direction = 'S';
      else
            child.direction = 'M';
}


void calc_distance(void)
{


float lat_sqr, lon_sqr, dist;

lat_sqr = (69.1*69.1*(child.latitude-parent.latitude)*(child.latitude-
parent.latitude));
lon_sqr = (53*53);
lon_sqr *= (child.longitude-parent.longitude)*(child.longitude-
parent.longitude);

dist = sqrt(lat_sqr + lon_sqr);//in miles
dist *= 5280.0;//in feet

child.distance = (long int)dist;
}



//void calc_distance(void)
//{
/*************************************************************************
**/
/*    Approximate distance in miles = sqrt(x * x + y * y)
            */
/*
                                    */
/*    where x = 69.1 * (lat2 - lat1)
                         */
/*    and y = 53 * (lon2 - lon1)
                        */
/*
                                    */
/*    You can improve the accuracy of this approximate distance
      */
/*     calculation by adding the cosine math function:
            */
/*
                                    */
/*    Approximate distance in miles = sqrt(x * x + y * y)
            */
```

```
/*
                                      */
/*    where x = 69.1 * (lat2 - lat1)
                       */
/*    and y = 69.1 * (lon2 - lon1) * cos(lat1/57.3)
              */
/*****************************************************************
**/

/*    float lat_sqr, lon_sqr, dist, more_accurate_calc;

      lat_sqr = (69.1*69.1*(child.latitude-
parent.latitude)*(child.latitude-parent.latitude));
      more_accurate_calc = cos((parent.latitude)/57.3);//only used for
more accurate calculation, can be taken out (cont.)
      lon_sqr = (69.1*69.1);
      lon_sqr *= more_accurate_calc * more_accurate_calc;//this line
can be taken out if not enough RAM (concluded)
      lon_sqr *= (child.longitude-parent.longitude)*(child.longitude-
parent.longitude);

      dist = sqrt(lat_sqr + lon_sqr);//in miles
      dist *= 5280.0;//in feet

      child.distance = (long int)dist;

}*/
```

Appendix F: Complete Parent Software

```
/* Parent Device Software */
/* Created by Team 20 Child Locator */

#device PIC16F877
#include <16F877.H>
#include "trans.h"
#include "serial.h"
#include "display.h"

#use fast_io(B)   //Decreases the number of lines in the output of Port
B
#include<stdlib.h>
#include<math.h>

#fuses HS,NOWDT,NOPROTECT

/* Declaring global variables */

struct child_struct           /* Global structure for storing child
information */
{
      boolean present;  /* Tells parent device if child is present
(switch info) */
      long int distance;      /* Distance from parent to child */
      char direction;         /* Relative direction from parent to
child */
      boolean oor;            /* Set if child[i] is out of range */
      boolean panic;          /* Set if child[i] sends a panic */

} child[4];

struct parent_struct    /* Global structure for storing parent
information */
{
      boolean panic;          /* Child Panic state */
      char direction;         /* N S E W Q Z M P */
}parent;

struct output_struct
      {
            char package_id;  /* Package id for transmission */
            char alarm_id;          /* Store parents alarm button
status */
            float latitude;         /* Latitude of the parent */
            float longitude;  /* Longitude of parent */
            char package_id_2;      /* Ending package id for
transmission */
      }to_child;

/* Start of main program */
main()
{
      struct input_struct                              /* Structure for
recieved data from child */
      {
```

```
            char package_id;              /* Package id for
transmission */
            char panic_and_child_id;      /* Child id and panic
information */
            long int distance;                  /* Distance from child
to parent */
            char direction;                     /* Relative direction
from parent to child */
            char package_id_2;                  /* Ending package id
for transmission */
      }*from_child;

      char input[7];                            /* Message recieved
from child */
      char *output;                             /* Message sent to
child */

      int i, j;                                       /* For loops in
code */
      boolean transmit_time = false;            /* Indicates time to
transmit request to child */
      boolean first_time = true;                /* Is it the first time
through the code*/
      int error;                                      /* Used for
checking errors on transmissions */
      int time;                                       /* Time recieved
from GPS */

      /* Used to control bus switch, these are set so the bus switch
isn't floating
         and the PIC doesn't recieve garbage */

      output_low(PIN_C4);
      output_low(PIN_C5);

      /* Delay to let GPS acquire satellites */
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(20000);
      delay_ms(20000);

      /* Making sure USART buffer is empty */
      error=receive(input,7);
      error=receive(input,7);
      error=receive(input,7);
      error=receive(input,7);
      error=receive(input,7);

      /* LCD initilization */
      set_tris_b(0x00); //sets port B to always output
      initialize_lcd(); //initializes the LCD
```

```
      create_arrows();  //creates the arrows for the direction not
already on the LCD
      display_on();           //Turn the LCD on and makes it ready to
display characters

      /* Set child1..4 out of range to false to begin with */
      child[1].oor = false;
      child[2].oor = false;
      child[3].oor = false;
      child[4].oor = false;

      /* Inital location, in case parent doesn't get coordinates */
      to_child.latitude = 0.0;
      to_child.longitude = 0.0;

      /* Testing purposes*/
      parent.direction = 'N';
      output_low(PIN_C1);

      /* Check external switches to see which children are present */
      if (input(PIN_D0))
            child[1].present = true;
      else
            child[1].present = false;
      if (input(PIN_D1))
            child[2].present = true;
      else
            child[2].present = false;
      if (input(PIN_D2))
            child[3].present = true;
      else
            child[3].present = false;
      if (input(PIN_D3))
            child[4].present = true;
      else
            child[4].present = false;

      /* Main loop of execution*/
      while(true)
      {
            /* Check if parent panic button is pressed */
            if (input(PIN_E0)==1)
            {
                  parent.panic = true;
                  output_high(PIN_A5);
            }
            else
            {
                  parent.panic = false;
                  output_low(PIN_A5);
            }

            /* Check if time to request child location */
            time = 0;
            while (!transmit_time)
            {
```

```
                  delay_ms(200);
                  if (time == 10)
                  {
                        transmit_time = true;
                  }
                  if(!first_time)
                  {
                        /* Uncomment get_compass if you want to use
compass, compass is useless if the
                           antenna is magnetic */
                        //get_compass();       /*function to get
compass info */
                        update_direction();     //updates the current
relative direction from
                  }
                  time++;
            }

            first_time = false;
            transmit_time = false;

            /* Get position from GPS */
            output_high(PIN_C4);
            output_low(PIN_C5);
            get_position();


            /* Get panic information ready to transmit to child devices
*/
            to_child.alarm_id= 0x00;      //Cleared so alarm
information can be set below
            for (i = 1; i<2; i++)
            {
                  if(child[i].present==true)
                  {
                        /* Set child ID and alarm information */
                        if (i==1)
                        {
                              if (child[i].oor == true)
                                    bit_set(to_child.alarm_id,3);
                              if (parent.panic == true)
                                    bit_set(to_child.alarm_id,4);
                        }
                        if ((i==2) || (i==3) || (i==4))
                        {
                              bit_set(to_child.alarm_id,(3+i));
                              if (child[i].oor == true)
                                    bit_set(to_child.alarm_id,(4-i));
                              if (parent.panic == true)
                                    bit_set(to_child.alarm_id,4);
                        }

                        /* Get ready to transmit */
                        to_child.package_id = 0x73;
                        to_child.package_id_2 = 0x37;
                        to_child.alarm_id = 0x00;
                        output=&to_child;
```

```
                        /* Get bus switch ready */
                        output_low(PIN_C4);
                        output_high(PIN_C5);
                        transceiver_transmit(output,11);

                        /* Recieve from child device */

                        error=transceiver_receive(input,6);
                        from_child=(struct input_struct *)input;

                        /* Recieve child i information if not recieved
before, this takes care of
                           frequency hopping of transciever.  Request
is sent until child recieves the
                           request*/
                        for (j = 1; j<10; j++)
                        {
                              if(error==0)
                              {
                                    delay_ms(10);
                                    output_low(PIN_C4);
                                    output_high(PIN_C5);
                                    transceiver_transmit(output,11);
                                    error=transceiver_receive(input,6);
                                    from_child=(struct input_struct
*)input;
                              }
                              /* If parent recieved a valid tranmission
before time expires break loop */
                              if(error==6 && from_child-
>package_id==0x73 && from_child->package_id_2==0x37)
                              {
                                    if (from_child->distance == 0)
                                    {
                                          output_high(PIN_C1);
                                    }
                                    child[i].distance= from_child-
>distance;
                                    child[i].direction = from_child-
>direction;
                                    j = 10;
                                    break;
                              }
                        }
                        /* Checks to see if child responded */
                        if(j >= 9)
                        {
                              child[i].oor = true;
                        }
                        /* If child responded check panic state of
child */
                        if(bit_test(from_child-
>panic_and_child_id,7)==1)
                        {
                              child[i].panic = true;
                        }
```

```
                        else
                        {
                              child[i].panic = false;
                        }

                        /* Determine if child is approaching range
limits */
                        if (child[i].distance > 2500)
                              child[i].oor = true;
                        else
                              child[i].oor = false;
                  }
            }
            /* Turn on parent alarm if any child devices are out of
2500 feet range */
            if((child[1].oor || child[2].oor || child[3].oor) == true)
                  output_high(PIN_A5);
            else
                  output_low(PIN_A5);
            /* Update LCD with each child's position and info */

            //Check Panic and OOR
            check_pan_oor();
            delay_ms(1000);

            //Display child names
            big_c();
            low_h();
            low_i();
            low_l();
            low_d();
            one();
            space();

            //Display the distance
            display_distance();
            low_f();
            low_t();

            //Display the directions
            //get_compass();
            display_direction();

            //Displays the rest of the children on the Display
            display_roc();
      }
}

/*************************************************************************
************************************************/
/************************/
/* Get lon and lat */
/************************/

void get_position()
{
   char output[8];
```

```
   char input[27];
   char crap;
   long int i;
   int data_length=0;
   float temp;
   float latitude;
   float longitude;

   //delay_ms(2000);
   output[0]=0x40;  // @
   output[1]=0x40;  // @
   output[2]=0x45;  // E
   output[3]=0x71;  // q
   output[4]=0x00;  // 0 for the mode of output(once)
   output[5]=0x34;  // Checksum for (Eq0)
   output[6]=0x0D;  // Carriage Return
   output[7]=0x0A;  // Line Feed

   data_length=receive(input,27);
   transmit(output,8);

   while(kbhit()==0)
   {
      delay_us(10);
   }

   data_length=receive(input,23);

   data_length=receive(input,27);


/* Conversion of the input[0-9] into floating point latitude  */

   latitude = (((int)input[0]-48)*10) + ((int)input[1]-48);
   temp = ((((int)input[3]-48) * 10) + ((int)input[4]-48));
   temp = temp + ((((int)input[6]-48)*.1) +(((int)input[7]-48)*.01));
   temp = temp + ((((int)input[8]-48)*.001) + (((int)input[9]-
48)*.0001));
   temp = temp/60;
   latitude = latitude + temp;
   if (latitude != 0.0)
   {
            to_child.latitude = latitude;
   }

/* Conversion of the input[13-26] into floating point longitude  */

   longitude = (((int)input[13]-48)*100);
   longitude = longitude + (((int)input[14]-48)*10) + ((int)input[15]-
48);
   temp = ((((int)input[17]-48) * 10) + ((int)input[18]-48));
   temp = temp + ((((int)input[20]-48)/10) +(((int)input[21]-48)/100));
   temp = temp + ((((int)input[22]-48)/1000) + (((int)input[23]-
48)/10000));
   temp = temp/60;
   longitude = longitude + temp;
   if (longitude != 0.0)
```

```
   {
            to_child.longitude = longitude;
   }

   data_length=receive(input,23);
   data_length=receive(input,26);

}
/*************************************/
/*  gets time from GPS                */
/*  outputs seconds as integer         */
/*************************************/
int get_time()
{
   char output[8];
   char input[22];
   int data_length=0;
   int time = 0;

   output[0]=0x40;  // @
   output[1]=0x40;  // @
   output[2]=0x45;  // E
   output[3]=0x71;  // q
   output[4]=0x00;  // 0 for the mode of output(once)
   output[5]=0x34;  // Checksum for (Eq0)
   output[6]=0x0D;  // Carriage Return
   output[7]=0x0A;  // Line Feed

   transmit(output,8);

   data_length=receive(input,22);

/* Conversion of the input[20-21] into integer seconds  */

   time = (((int)input[20]-48)*10) + ((int)input[21]-48);
   return time;

}

/*************************************/
/*  transmits first n characters of the */
/*  output array where n=length         */
/*************************************/
void transmit(char output[20], int length)
{
   int i=0;

   for(i=0;i<length;i++)
   {
      putc(output[i]);
   }
}


/*************************************/
/* receives n characters and stores    */
/* them in the first n elements of the */
```

```
/* input array where n=length and is   */
/* NOT equal to 0.  If lenght=0, it    */
/* continues to get characters data    */
/* it receives a carriage return       */
/*************************************/
int receive(char input[20], int length)
{
   char data='a';
   long int timeout=0;
   int i=0;
   int kbhit=0;

   //timeout=0;
   //if(length==0)
   //{
   //  while(data != 0x0D)
   //  {
   //     kbhit=kbhit();
//
            /* wait max of 20 ms */
//          while((kbhit==0)&&(++timeout<2000))
//          {
//                delay_us(10);
//                kbhit=kbhit();
//          }

//          if(timeout>=2000)
//                return 0;

//          if(kbhit)
//          {
//                data=getc();
//                input[i] = data;
//                i++;
//          }
//          else
//        {
//                return i;
//        }
//    }
//   }
//   else
//   {

//          input[0]=0x00;
//          input[1]=0x0B;
//          input[2]=0x73;
//          input[3]=0x10;
//          input[4]=0x00;
//          input[5]=0x00;
//          input[6]=0x00;
//          input[7]=0x00;
//          input[8]=0x00;
//          input[9]=0x00;
//          input[10]=0x00;
//          input[11]=0x00;
//          input[12]=0x37;
```

```
//          return 13;
            while(i<length)
            {

                  timeout=0;
                  kbhit=kbhit();

                  /* wait max of 20 ms */
                  while((kbhit==0)&&(++timeout<2000))
                  {
                        delay_us(10);
                        kbhit=kbhit();
                  }
                  if(kbhit)
                  {
                        data=getc();
                        input[i] = data;
                        i++;
                  }
                  else
                  {
                        return i;
                  }
            }
//   }

   return i;
}
/************************************************/
/*                                      */
/*  transceiver transmit                        */
/*                                      */
/************************************************/
void transceiver_transmit(char data[20], int length)
{
      char output[20];

      output[0]=PREAMBLE;
      output[1]=PREAMBLE;
      output[2]=PREAMBLE;
      output[3]=SYNC;
      output[4]=0x00;
      output[5]=(char)length;

      //BUS SWITCH CODE

      //make sure the transceiver is not in hopping state
      while(input(DSR)!=1)
      {
            delay_us(10);
      }

      output_low(TE);
      while(input(CTS)!=0)
      {
            delay_ms(1);
      }
```

```
	transmit(output,6);
	transmit(data,length);

	output_high(TE);
	while(input(CTS)!=1)
	{
		delay_us(10);
	}

	//if the transceiver has hopped while transmitting repeat
transmission
	if(input(DSR)==0)
	{
		//clear latch

		//transceiver_transmit(data,length);
	}
}


/************************************************/
/*
*/
/*  transceiver receive                          */
/*
*/
/************************************************/
int transceiver_receive(char data[20],int length)
{
	long int len,i=0;
	char receive_data[20];


	//BUS SWITCH CODE

	/* receive length+2 bytes -> accounts for lenght high and low
bytes from transceiver */
	for(i=0;i<8000;i++)
	{
		if(kbhit() == 1)
		{
			break;
		}

		delay_ms(1);
	}

	if(i<8000)
	{
	len=receive(receive_data,length+2);

	/* strip the length_high and length_low bytes off of transmission
*/
	for(i=0;i<len-2;i++)
	{
		data[i]=receive_data[i+2];
```

```
	}

	return (int)receive_data[1];
	}
	else
	{
		return 0;
	}
}
/*****************************************************/
/*
	*/
/*	displays the information about the rest of the  */
/*	children
	*/
/*
	*/
/*****************************************************/
void display_roc(void)
{
	block();
	block();
	big_c();
	low_h();
	low_i();
	low_l();
	low_d();
	three();
	space();

	pound();
	pound();
	pound();
	pound();
	low_f();
	low_t();
	block();

	line2();

	block();
	block();
	big_c();
	low_h();
	low_i();
	low_l();
	low_d();
	two();
	space();

	pound();
	pound();
	pound();
	pound();
	low_f();
	low_t();
	block();
```

```
      block();
      block();
      big_c();
      low_h();
      low_i();
      low_l();
      low_d();
      four();
      space();

      pound();
      pound();
      pound();
      pound();
      low_f();
      low_t();
      block();
}
/*****************************************************/
/*
      */
/*    updates the direction of the children                */
/*
      */
/*****************************************************/
void update_direction(void)
{
      int i;

      line1();                        //calls line 1 on the LCD
      for(i=0;i<15;i++)
            cursor_move_right();//moves the cursor on the LCD 16 spaces
to the right
      display_direction();    //calculates and displays the updated
direction
}
/*****************************************************/
/*
      */
/*    displays the direction about all of the              */
/*    children
      */
/*
      */
/*****************************************************/
void display_direction(void)
{
      long int pdir, cdir;
      char pcdir, ccdir;

      pcdir = parent.direction;
      ccdir = child[1].direction;

      pdir = get_dir(pcdir);
      cdir = get_dir(ccdir);
```

```
	pdir = pdir - cdir;

	if(pdir == 0 || pdir == 360 || pdir == -360)
		up_arrow();
	else if(pdir == 45 || pdir == -315 || pdir == 405)
		top_right_arrow();
	else if(pdir == 90 || pdir == 450 || pdir == -270)
		right_arrow();
	else if(pdir == 135 || pdir == 495 || pdir == -225)
		bottom_right_arrow();
	else if(pdir == 180 || pdir == 540 || pdir == -180)
		down_arrow();
	else if(pdir == 225 || pdir == 585 || pdir == -135)
		bottom_left_arrow();
	else if(pdir == 270 || pdir == 630 || pdir == -90)
		left_arrow();
	else
		top_left_arrow();
}
/*************************************************/
/*
	*/
/*	gets a numerical representation of the character*/
/*	direction for the children                                */
/*
	*/
/*************************************************/
long int get_dir(char dir)
{
	long int d;
	switch(dir)
	{
	case 'N':
		d = 90;
		break;
	case 'Q':
		d = 135;
		break;
	case 'W':
		d = 180;
		break;
	case 'Z':
		d = 225;
		break;
	case 'S':
		d = 270;
		break;
	case 'M':
		d = 315;
		break;
	case 'E':
		d = 0;
		break;
	default:
		d = 45;
		break;
	}
```

```
	return d;
}
/*************************************************/
/*
	*/
/*	displays the distance for the children		*/
/*
	*/
/*************************************************/
void display_distance(void)
{
	long int mult, ch_distance;
	short int num = 0;
	ch_distance = child[1].distance;
	if(child[1].distance <= 9999)
	{
		mult = ch_distance;
		mult = mult / 1000;
		if(mult >= 1)
		{
			display_num(mult);
			ch_distance = ch_distance - (mult * 1000);
			num = 1;
		}
		else if(mult == 0)
		{
			space();
		}
		mult = ch_distance;
		mult = mult / 100;
		if(mult >= 1)
		{
			display_num(mult);
			ch_distance = ch_distance - (mult * 100);
			num = 1;
		}
		else if(mult == 0)
		{
			if(num == 0)
				space();
			else
				zero();
		}
		mult = ch_distance;
		mult = mult / 10;
		if(mult >= 1)
		{
			display_num(mult);
			ch_distance = ch_distance - (mult * 10);
			num = 1;
		}
		else if(mult == 0)
		{
			if(num == 0)
				space();
			else
				zero();
```

```
            }
            mult = ch_distance;
            if(mult >= 1)
            {
                  display_num(mult);
            }
            else if(floor(mult) == 0)
                  zero();
      }
      else
      {
            pound();
            pound();
            pound();
            pound();
      }
}
/*****************************************************/
/*
      */
/*    function called from display_distance() to           */
/*    display the number characters to the LCD       */
/*
      */
/*****************************************************/
void display_num(int mult)
{
      int i;
      switch(mult)
      {
      case 1:
            one();
            break;
      case 2:
            two();
            break;
      case 3:
            three();
            break;
      case 4:
            four();
            break;
      case 5:
            five();
            break;
      case 6:
            six();
            break;
      case 7:
            seven();
            break;
      case 8:
            eight();
            break;
      case 9:
            nine();
            break;
```

```
      default:
            zero();
            break;
      }
}
/*************************************************/
/*
      */
/*    displays to the LCD whether or not the panic    */
/*    or out of range are set for a child                  */
/*
      */
/*************************************************/
void check_pan_oor(void)
{
      if(child[1].present == true)
      {
            line1();
            if(child[1].panic == true)
                  block();
            else
                  space();
            if(child[1].oor == true)
                  block();
            else
                  space();
      }
      else
      {
            space();
            space();
      }
}
/*************************************************/
/*
      */
/*    initialized the LCD
      */
/*
      */
/*************************************************/
void initialize_lcd(void)
{
      delay_ms(100);                //Wait more than 15ms after Vcc =
4.5V
                                          // the number was made to be
100ms because
                                          // of the wider voltage
operating range of
                                          // the PIC compared to that
of the LCD

      output_low(PIN_B1);
      delay_ms(1);
```

```
      output_low(PIN_B2);           //Function set: Sets interface to
4-bit
      output_low(PIN_B3);
      output_low(PIN_B4);           //0010
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();


      //output_low(PIN_B2);         //Function set: (Interface = 4-bit,
Set N and F
      //output_low(PIN_B3);         // for number of lines and
character font)
      output_low(PIN_B4);           //0010
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_low(PIN_B2);
      //output_low(PIN_B3);
      output_low(PIN_B4);           //1000
      output_low(PIN_B5);
      output_low(PIN_B6);
      output_high(PIN_B7);

      enable_hl();

      //output_low(PIN_B2);               //Display ON
      //output_low(PIN_B3);
      output_low(PIN_B4);               //0000
      output_low(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_low(PIN_B2);
      //output_low(PIN_B3);
      output_low(PIN_B4);               //1110
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_high(PIN_B7);

      enable_hl();

      //output_low(PIN_B2);               //Entry Mode Set:
      //output_low(PIN_B3);
      output_low(PIN_B4);               //0000
      output_low(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();
```

```
	//output_low(PIN_B2);
	//output_low(PIN_B3);
	output_low(PIN_B4);                  //0110
	output_high(PIN_B5);
	output_high(PIN_B6);
	output_low(PIN_B7);

	enable_hl();
}

//LINES OF DISPLAY
void line1(void)
{
	//line one and three

	output_low(PIN_B2);//rs low
	output_low(PIN_B3);
	output_low(PIN_B4);//1000
	output_low(PIN_B5);
	output_low(PIN_B6);
	output_high(PIN_B7);

	enable_hl();

	//output_low(PIN_B2);
	//output_low(PIN_B3);
	output_low(PIN_B4);//0000
	output_low(PIN_B5);
	output_low(PIN_B6);
	output_low(PIN_B7);

	enable_hl();

}
void line2(void)
{
	//line two and four
	output_low(PIN_B2);//rs low
	output_low(PIN_B3);

	output_low(PIN_B4);//1100
	output_low(PIN_B5);
	output_high(PIN_B6);
	output_high(PIN_B7);

	enable_hl();

	output_low(PIN_B4);//0000
	output_low(PIN_B5);
	output_low(PIN_B6);
	output_low(PIN_B7);

	enable_hl();
}

void cursor_move_left(void)
```

```
{
      output_low(PIN_B2);//RS LOW
      output_low(PIN_B3);//R/W LOW

      output_high(PIN_B4);//0001
      output_low(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      output_low(PIN_B4);//0000
      output_low(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

}

void cursor_move_right(void)
{
      output_low(PIN_B2);//RS LOW
      output_low(PIN_B3);//R/W LOW

      output_high(PIN_B4);//0001
      output_low(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      output_low(PIN_B4);//0100
      output_low(PIN_B5);
      output_high(PIN_B6);
      output_low(PIN_B7);

      enable_hl();
}
//DECIMAL
void decimal(void)
{

      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_low(PIN_B4);           //->0010 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_low(PIN_B4);     //->1110 LOW ORDER NIBBLE
```

```
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_high(PIN_B7);

      enable_hl();
}

//NUMBERS
//zero
void zero(void)
{
      //output_low(PIN_B1);         //E LOW
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_high(PIN_B4);    //->0011 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_low(PIN_B4);           //->0000 LOW ORDER NIBBLE
      output_low(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();
}

//one
void one(void)
{
      //output_low(PIN_B1);         //E LOW
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_high(PIN_B4);    //->0011 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_high(PIN_B4);    //->0001 LOW ORDER NIBBLE
      output_low(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();
}
```

```
//two
void two(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_high(PIN_B4);    //->0011 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_low(PIN_B4);           //->0010 LOW ORDER NIBBLE
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();
}

//three
void three(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_high(PIN_B4);    //->0011 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_high(PIN_B4);    //->0011 LOW ORDER NIBBLE
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();
}

//four
void four(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_high(PIN_B4);    //->0011 HIGH ORDER NIBBLE
      output_high(PIN_B5);
```

```
	output_low(PIN_B6);
	output_low(PIN_B7);

	enable_hl();

	//output_high(PIN_B2);  //RS TO HIGH
	//output_low(PIN_B3);         //R/W TO LOW

	output_low(PIN_B4);           //->0100 LOW ORDER NIBBLE
	output_low(PIN_B5);
	output_high(PIN_B6);
	output_low(PIN_B7);

	enable_hl();

}

//five
void five(void)
{
	output_high(PIN_B2);    //RS TO HIGH
	output_low(PIN_B3);     //R/W TO HIGH

	output_high(PIN_B4);    //->0011 HIGH ORDER NIBBLE
	output_high(PIN_B5);
	output_low(PIN_B6);
	output_low(PIN_B7);

	enable_hl();

	//output_high(PIN_B2);  //RS TO HIGH
	//output_low(PIN_B3);         //R/W TO LOW

	output_high(PIN_B4);    //->0101 LOW ORDER NIBBLE
	output_low(PIN_B5);
	output_high(PIN_B6);
	output_low(PIN_B7);

	enable_hl();
}

//six
void six(void)
{
	output_high(PIN_B2);    //RS TO HIGH
	output_low(PIN_B3);     //R/W TO HIGH

	output_high(PIN_B4);    //->0011 HIGH ORDER NIBBLE
	output_high(PIN_B5);
	output_low(PIN_B6);
	output_low(PIN_B7);

	enable_hl();

	//output_high(PIN_B2);  //RS TO HIGH
	//output_low(PIN_B3);         //R/W TO LOW
```

```
      output_low(PIN_B4);           //->0110 LOW ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_low(PIN_B7);

      enable_hl();
}

//seven
void seven(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_high(PIN_B4);    //->0011 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_high(PIN_B4);    //->0111 LOW ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_low(PIN_B7);

      enable_hl();
}

//eight
void eight(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_high(PIN_B4);    //->0011 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_low(PIN_B4);           //->1000 LOW ORDER NIBBLE
      output_low(PIN_B5);
      output_low(PIN_B6);
      output_high(PIN_B7);

      enable_hl();
}

//nine
```

```
void nine(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_high(PIN_B4);    //->0011 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_high(PIN_B4);    //->1001 LOW ORDER NIBBLE
      output_low(PIN_B5);
      output_low(PIN_B6);
      output_high(PIN_B7);

      enable_hl();
}

//CHARACTERS
//Space
void space(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_low(PIN_B4);           //->0010 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_low(PIN_B4);           //->0000 LOW ORDER NIBBLE
      output_low(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);

      enable_hl();
}

void pound(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_low(PIN_B4);           //->0010 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_low(PIN_B6);
      output_low(PIN_B7);
```

```
	enable_hl();

	//output_high(PIN_B2);  //RS TO HIGH
	//output_low(PIN_B3);         //R/W TO LOW

	output_high(PIN_B4);          //->0011 LOW ORDER NIBBLE
	output_high(PIN_B5);
	output_low(PIN_B6);
	output_low(PIN_B7);

	enable_hl();
}

//C
void big_c(void)
{
	output_high(PIN_B2);    //RS TO HIGH
	output_low(PIN_B3);     //R/W TO HIGH

	output_low(PIN_B4);           //->0100 HIGH ORDER NIBBLE
	output_low(PIN_B5);
	output_high(PIN_B6);
	output_low(PIN_B7);

	enable_hl();

	//output_high(PIN_B2);  //RS TO HIGH
	//output_low(PIN_B3);         //R/W TO LOW

	output_high(PIN_B4);    //->0011 LOW ORDER NIBBLE
	output_high(PIN_B5);
	output_low(PIN_B6);
	output_low(PIN_B7);

	enable_hl();

}

//h
void low_h(void)
{
	output_high(PIN_B2);    //RS TO HIGH
	output_low(PIN_B3);     //R/W TO HIGH

	output_low(PIN_B4);           //->0110 HIGH ORDER NIBBLE
	output_high(PIN_B5);
	output_high(PIN_B6);
	output_low(PIN_B7);

	enable_hl();

	//output_high(PIN_B2);  //RS TO HIGH
	//output_low(PIN_B3);         //R/W TO LOW

	output_low(PIN_B4);           //->1000 LOW ORDER NIBBLE
	output_low(PIN_B5);
```

```
      output_low(PIN_B6);
      output_high(PIN_B7);

      enable_hl();
}

//i
void low_i(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_low(PIN_B4);           //->0110 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_high(PIN_B4);    //->1001 LOW ORDER NIBBLE
      output_low(PIN_B5);
      output_low(PIN_B6);
      output_high(PIN_B7);

      enable_hl();
}

//l
void low_l(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_low(PIN_B4);           //->0110 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_low(PIN_B4);           //->1100 LOW ORDER NIBBLE
      output_low(PIN_B5);
      output_high(PIN_B6);
      output_high(PIN_B7);

      enable_hl();
}

//d
void low_d(void)
{
```

```
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_low(PIN_B4);           //->0110 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_low(PIN_B4);           //->0100 LOW ORDER NIBBLE
      output_low(PIN_B5);
      output_high(PIN_B6);
      output_low(PIN_B7);

      enable_hl();
}

//f
void low_f(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_low(PIN_B4);           //->0110 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_low(PIN_B4);           //->0110 LOW ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_low(PIN_B7);

      enable_hl();
}

//t
void low_t(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO LOW

      output_high(PIN_B4);    //->0111 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_low(PIN_B7);

      enable_hl();
```

```
      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_low(PIN_B4);           //->0100 LOW ORDER NIBBLE
      output_low(PIN_B5);
      output_high(PIN_B6);
      output_low(PIN_B7);

      enable_hl();
}

void low_n(void)
{
      //0110
      //1110
}
void low_o(void)
{
      //0110
      //1111
}
void low_u(void)
{
      //0111
      //0101
}


//BLOCK FOR VISIBLE ALARMS
void block(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_high(PIN_B4);    //->1111 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_high(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_high(PIN_B4);    //->1111 LOW ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_high(PIN_B7);

      enable_hl();
}


//ARROWS
//right arrow
void right_arrow(void)
```

```
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_high(PIN_B4);          //->0111 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_low(PIN_B4);     //->1110 LOW ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_high(PIN_B7);

      enable_hl();
}

//left arrow
void left_arrow(void)
{
      output_high(PIN_B2);    //RS TO HIGH
      output_low(PIN_B3);     //R/W TO HIGH

      output_high(PIN_B4);          //->0111 HIGH ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_low(PIN_B7);

      enable_hl();

      //output_high(PIN_B2);  //RS TO HIGH
      //output_low(PIN_B3);         //R/W TO LOW

      output_high(PIN_B4);          //->1111 LOW ORDER NIBBLE
      output_high(PIN_B5);
      output_high(PIN_B6);
      output_high(PIN_B7);

      enable_hl();
}
void enable_hl(void)
{
      output_high(PIN_B1);    //E HIGH, DATA BEING SENT TO LCD
      delay_ms(1);
      output_low(PIN_B1);           //E LOW, STOP OF DATA TRANSFER
      delay_ms(1);
}
void create_arrows(void)
{
      //SET CG RAM ADDRESS TO 1ST CHAR 0
      output_low(PIN_B2);//rsl();//00 01000000//Set CG RAM address
      output_low(PIN_B3);//rwl();
```

```
output_low(PIN_B7);//s7l();
output_high(PIN_B6);//s6h();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_low(PIN_B7);//t3l();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_low(PIN_B4);//zl();

enable_hl();
////////////////////////////////

//WRITE DATA TO CG RAM FOR TOP_RIGHT_ARROW()////
output_high(PIN_B2);//rsh();//10 00001111
output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_high(PIN_B7);//t3h();
output_high(PIN_B6);//t2h();
output_high(PIN_B5);//oh();
output_high(PIN_B4);//zh();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00000011
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_low(PIN_B7);//t3l();
output_low(PIN_B6);//t2l();
output_high(PIN_B5);//oh();
output_high(PIN_B4);//zh();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00000101
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();
```

```
output_low(PIN_B7);//t3l();
output_high(PIN_B6);//t2h();
output_low(PIN_B5);//ol();
output_high(PIN_B4);//zh();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00001001
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_high(PIN_B7);//t3h();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_high(PIN_B4);//zh();

enable_hl();

//output_high(PIN_B2);//rsh();//10 01001000
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_high(PIN_B6);//s6h();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_high(PIN_B7);//t3h();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_low(PIN_B4);//zl();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00001000
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_high(PIN_B7);//t3h();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_low(PIN_B4);//zl();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00010000
//output_low(PIN_B3);//rwl();
```

```
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_high(PIN_B4);//f4h();

enable_hl();

output_low(PIN_B7);//t3l();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_low(PIN_B4);//zl();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00000000
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_low(PIN_B7);//t3l();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_low(PIN_B4);//zl();

enable_hl();
////////////END OF WRITING 1ST CHAR 0////////////



//SET CG RAM ADDRESS TO 2ND CHAR 1
output_low(PIN_B2);//rsl();//00 01001000//Set CG RAM address
output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_high(PIN_B6);//s6h();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_high(PIN_B7);//t3l();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_low(PIN_B4);//zl();

enable_hl();
////////////////////////////////////

//WRITE DATA TO CG RAM FOR BOTTOM_RIGHT_ARROW()////
output_high(PIN_B2);//rsh();//10 00010000
output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
```

```
output_high(PIN_B4);//f4h();

enable_hl();

output_low(PIN_B7);//t3l();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_low(PIN_B4);//zl();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00001000
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_high(PIN_B7);//t3h();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_low(PIN_B4);//zl();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00001000
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_high(PIN_B7);//t3h();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_low(PIN_B4);//zl();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00001001
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_high(PIN_B7);//t3h();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_high(PIN_B4);//zh();
```

```
enable_hl();

//output_high(PIN_B2);//rsh();//10 01000101
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_high(PIN_B6);//s6h();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_low(PIN_B7);//t3l();
output_high(PIN_B6);//t2h();
output_low(PIN_B5);//ol();
output_high(PIN_B4);//zh();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00000011
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_low(PIN_B7);//t3l();
output_low(PIN_B6);//t2l();
output_high(PIN_B5);//oh();
output_high(PIN_B4);//zh();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00001111
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_high(PIN_B7);//t3h();
output_high(PIN_B6);//t2h();
output_high(PIN_B5);//oh();
output_high(PIN_B4);//zh();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00000000
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();
```

```
enable_hl();

output_low(PIN_B7);//t3l();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_low(PIN_B4);//zl();

enable_hl();
////////////END OF WRITING 2ND CHAR 1///////////

//SET CG RAM ADDRESS TO 3RD CHAR 2
output_low(PIN_B2);//rsl();//00 01010000//Set CG RAM address
output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_high(PIN_B6);//s6h();
output_low(PIN_B5);//fl();
output_high(PIN_B4);//f4h();

enable_hl();

output_low(PIN_B7);//t3l();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_low(PIN_B4);//zl();

enable_hl();
////////////////////////////////////

//WRITE DATA TO CG RAM FOR BOTTOM_LEFT_ARROW()////
output_high(PIN_B2);//rsh();//10 00000001
output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_low(PIN_B7);//t3l();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_high(PIN_B4);//zh();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00000010
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_low(PIN_B7);//t3h();
output_low(PIN_B6);//t2l();
output_high(PIN_B5);//ol();
```

```
output_low(PIN_B4);//zl();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00000010
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_low(PIN_B7);//t3h();
output_low(PIN_B6);//t2l();
output_high(PIN_B5);//ol();
output_low(PIN_B4);//zl();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00010010
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_high(PIN_B4);//f4l();

enable_hl();

output_low(PIN_B7);//t3h();
output_low(PIN_B6);//t2l();
output_high(PIN_B5);//ol();
output_low(PIN_B4);//zh();

enable_hl();

//output_high(PIN_B2);//rsh();//10 01010100
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_high(PIN_B6);//s6h();
output_low(PIN_B5);//fl();
output_high(PIN_B4);//f4l();

enable_hl();

output_low(PIN_B7);//t3l();
output_high(PIN_B6);//t2h();
output_low(PIN_B5);//ol();
output_low(PIN_B4);//zh();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00011000
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
```

```
output_high(PIN_B4);//f4l();

enable_hl();

output_high(PIN_B7);//t3l();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//oh();
output_low(PIN_B4);//zh();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00011110
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_high(PIN_B4);//f4l();

enable_hl();

output_high(PIN_B7);//t3h();
output_high(PIN_B6);//t2h();
output_high(PIN_B5);//oh();
output_low(PIN_B4);//zh();

enable_hl();

//output_high(PIN_B2);//rsh();//10 00000000
//output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_low(PIN_B6);//s6l();
output_low(PIN_B5);//fl();
output_low(PIN_B4);//f4l();

enable_hl();

output_low(PIN_B7);//t3l();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
output_low(PIN_B4);//zl();

enable_hl();
////////////END OF WRITING 3ND CHAR 2////////////

//SET CG RAM ADDRESS TO 4TH CHAR 3
output_low(PIN_B2);//rsl();//00 01011000//Set CG RAM address
output_low(PIN_B3);//rwl();
output_low(PIN_B7);//s7l();
output_high(PIN_B6);//s6h();
output_low(PIN_B5);//fl();
output_high(PIN_B4);//f4l();

enable_hl();

output_high(PIN_B7);//t3l();
output_low(PIN_B6);//t2l();
output_low(PIN_B5);//ol();
```

```
      output_low(PIN_B4);//zl();

      enable_hl();
      ////////////////////////////////

      //WRITE DATA TO CG RAM FOR TOP_RIGHT_ARROW()////
      output_high(PIN_B2);//rsh();//10 00011110
      output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_high(PIN_B4);//f4l();

      enable_hl();

      output_high(PIN_B7);//t3h();
      output_high(PIN_B6);//t2h();
      output_high(PIN_B5);//oh();
      output_low(PIN_B4);//zh();

      enable_hl();

      //output_high(PIN_B2);//rsh();//10 00011000
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_high(PIN_B4);//f4l();

      enable_hl();

      output_high(PIN_B7);//t3l();
      output_low(PIN_B6);//t2l();
      output_low(PIN_B5);//oh();
      output_low(PIN_B4);//zh();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00010100
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_high(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3l();
      output_high(PIN_B6);//t2h();
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zh();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00010010
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
```

```
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_high(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3h();
      output_low(PIN_B6);//t2l();
      output_high(PIN_B5);//ol();
      output_low(PIN_B4);//zh();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 01000010
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_high(PIN_B6);//s6h();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3h();
      output_low(PIN_B6);//t2l();
      output_high(PIN_B5);//ol();
      output_low(PIN_B4);//zl();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00000010
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3h();
      output_low(PIN_B6);//t2l();
      output_high(PIN_B5);//ol();
      output_low(PIN_B4);//zl();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00000001
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4h();

      enable_hl();

      output_low(PIN_B7);//t3l();
      output_low(PIN_B6);//t2l();
      output_low(PIN_B5);//ol();
```

```
      output_high(PIN_B4);//zl();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00000000
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3l();
      output_low(PIN_B6);//t2l();
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zl();

      enable_hl();
      ////////////END OF WRITING 4TH CHAR 3///////////

      //SET CG RAM ADDRESS TO 5TH CHAR 4
      output_low(PIN_B2);//rsl();//00 01100000//Set CG RAM address
      output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_high(PIN_B6);//s6h();
      output_high(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3l();
      output_low(PIN_B6);//t2l();
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zl();

      enable_hl();
      ////////////////////////////////////

      //  1
      // 111
      //1 1 1
      //  1
      //  1
      //  1
      //  1

      //WRITE DATA TO CG RAM FOR UP_ARROW()////
      output_high(PIN_B2);//rsh();//10 00000100
      output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();
```

```
      output_low(PIN_B7);//t3h();
      output_high(PIN_B6);//t2h();
      output_low(PIN_B5);//oh();
      output_low(PIN_B4);//zh();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00001110
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_high(PIN_B7);//t3l();
      output_high(PIN_B6);//t2l();
      output_high(PIN_B5);//oh();
      output_low(PIN_B4);//zh();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00010101
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_high(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3l();
      output_high(PIN_B6);//t2h();
      output_low(PIN_B5);//ol();
      output_high(PIN_B4);//zh();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00000100
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3h();
      output_high(PIN_B6);//t2l();
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zh();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 01000100
//    output_low(PIN_B3);//rwl();
```

```
      output_low(PIN_B7);//s7l();
      output_high(PIN_B6);//s6h();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3h();
      output_high(PIN_B6);//t2l();
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zl();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00000100
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3h();
      output_high(PIN_B6);//t2l();
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zl();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00000100
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4h();

      enable_hl();

      output_low(PIN_B7);//t3l();
      output_high(PIN_B6);//t2l();
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zl();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00000000
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3l();
      output_low(PIN_B6);//t2l();
```

```
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zl();

      enable_hl();
      ////////////END OF WRITING 5TH CHAR 4////////////

      //SET CG RAM ADDRESS TO 6TH CHAR 5
      output_low(PIN_B2);//rsl();//00 01101000//Set CG RAM address
      output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_high(PIN_B6);//s6h();
      output_high(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_high(PIN_B7);//t3l();
      output_low(PIN_B6);//t2l();
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zl();

      enable_hl();
      ////////////////////////////////////

      //  1
      //  1
      //  1
      //  1
      //1 1 1
      // 111
      //  1

      //WRITE DATA TO CG RAM FOR UP_ARROW()////
      output_high(PIN_B2);//rsh();//10 00000100
      output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3h();
      output_high(PIN_B6);//t2h();
      output_low(PIN_B5);//oh();
      output_low(PIN_B4);//zh();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00000100
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();
```

```
      output_low(PIN_B7);//t3l();
      output_high(PIN_B6);//t2l();
      output_low(PIN_B5);//oh();
      output_low(PIN_B4);//zh();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00000100
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3l();
      output_high(PIN_B6);//t2h();
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zh();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00000100
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3h();
      output_high(PIN_B6);//t2l();
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zh();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 01010101
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_high(PIN_B6);//s6h();
      output_low(PIN_B5);//fl();
      output_high(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3h();
      output_high(PIN_B6);//t2l();
      output_low(PIN_B5);//ol();
      output_high(PIN_B4);//zl();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00001110
```

```
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_high(PIN_B7);//t3h();
      output_high(PIN_B6);//t2l();
      output_high(PIN_B5);//ol();
      output_low(PIN_B4);//zl();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00000100
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4h();

      enable_hl();

      output_low(PIN_B7);//t3l();
      output_high(PIN_B6);//t2l();
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zl();

      enable_hl();

//    output_high(PIN_B2);//rsh();//10 00000000
//    output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3l();
      output_low(PIN_B6);//t2l();
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zl();

      enable_hl();
      ////////////END OF WRITING 6TH CHAR 5/////////////


      ////////SET DD RAM ADDRESS TO BEGINNING/////////
      output_low(PIN_B2);//rsl();//00 00000000//Set DD RAM address
      output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();
```

```
      enable_hl();

      output_low(PIN_B7);//t3l();
      output_low(PIN_B6);//t2l();
      output_low(PIN_B5);//ol();
      output_low(PIN_B4);//zl();

      enable_hl();
      ////////////////////////////////////////////////
}
void display_on(void)
{
      output_low(PIN_B2);//rsl();//00 00001110
      output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_high(PIN_B7);//t3h();
      output_high(PIN_B6);//t2h();
      output_high(PIN_B5);//oh();
      output_low(PIN_B4);//zl();

      enable_hl();
}
//up arrow
void up_arrow(void)
{
      output_high(PIN_B2);//rsh();//10 00000100
      output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();

      enable_hl();

      output_low(PIN_B7);//t3l();
      output_high(PIN_B6);//t2l();
      output_low(PIN_B5);//oh();
      output_low(PIN_B4);//zl();

      enable_hl();
}
//down arrow
void down_arrow(void)
{
      output_high(PIN_B2);//rsh();//10 00000101
      output_low(PIN_B3);//rwl();
      output_low(PIN_B7);//s7l();
      output_low(PIN_B6);//s6l();
      output_low(PIN_B5);//fl();
      output_low(PIN_B4);//f4l();
```

```
	enable_hl();

	output_low(PIN_B7);//t3l();
	output_high(PIN_B6);//t2l();
	output_low(PIN_B5);//oh();
	output_high(PIN_B4);//zl();

	enable_hl();
}
//top left arrow
void top_left_arrow(void)
{
	output_high(PIN_B2);//rsh();//10 00000011
	output_low(PIN_B3);//rwl();
	output_low(PIN_B7);//s7l();
	output_low(PIN_B6);//s6l();
	output_low(PIN_B5);//fl();
	output_low(PIN_B4);//f4l();

	enable_hl();

	output_low(PIN_B7);//t3l();
	output_low(PIN_B6);//t2l();
	output_high(PIN_B5);//oh();
	output_high(PIN_B4);//zl();

	enable_hl();
}
//top right arrow
void top_right_arrow(void)
{
	output_high(PIN_B2);//rsh();//10 00000000
	output_low(PIN_B3);//rwl();
	output_low(PIN_B7);//s7l();
	output_low(PIN_B6);//s6l();
	output_low(PIN_B5);//fl();
	output_low(PIN_B4);//f4l();

	enable_hl();

	output_low(PIN_B7);//t3l();
	output_low(PIN_B6);//t2l();
	output_low(PIN_B5);//ol();
	output_low(PIN_B4);//zl();

	enable_hl();
}
//bottom left arrow
void bottom_left_arrow(void)
{
	output_high(PIN_B2);//rsh();//10 00000010
	output_low(PIN_B3);//rwl();
	output_low(PIN_B7);//s7l();
	output_low(PIN_B6);//s6l();
	output_low(PIN_B5);//fl();
	output_low(PIN_B4);//f4l();
```

```
	enable_hl();

	output_low(PIN_B7);//t3l();
	output_low(PIN_B6);//t2l();
	output_high(PIN_B5);//oh();
	output_low(PIN_B4);//zl();

	enable_hl();
}
//bottom right arrow
void bottom_right_arrow(void)
{
	output_high(PIN_B2);//rsh();//10 00000001
	output_low(PIN_B3);//rwl();
	output_low(PIN_B7);//s7l();
	output_low(PIN_B6);//s6l();
	output_low(PIN_B5);//fl();
	output_low(PIN_B4);//f4l();

	enable_hl();

	output_low(PIN_B7);//t3l();
	output_low(PIN_B6);//t2l();
	output_low(PIN_B5);//oh();
	output_high(PIN_B4);//zl();

	enable_hl();
}

char get_compass(void) {

/* Check to see the orientation of parent device */


//char direction;



	if ((!(input(PIN_A0))) && (!(input(PIN_A1))))
		parent.direction = 'Q';//NE
	  else if ((!(input(PIN_A0))) && (!(input(PIN_A3))))
		parent.direction = 'Z';//NW
	else if ((!(input(PIN_A2))) && (!(input(PIN_A1))))
		parent.direction = 'P';//SE
	else if ((!(input(PIN_A2))) && (!(input(PIN_A3))))
		parent.direction = 'M';//SW
	else if (!(input(PIN_A0)))
		parent.direction = 'W';//N
	else if (!(input(PIN_A1)))
		parent.direction = 'N';//E
	else if (!(input(PIN_A2)))
		parent.direction = 'E';//S
	else if (!(input(PIN_A3)))
		parent.direction = 'S';//W

	//return direction;
}
```

Appendix G: Header files for Parent and Child Software

Serial.h

```
#use delay(clock=20000000)

#use rs232(baud=9600, xmit=PIN_C6, rcv=PIN_C7)  //initialize
USART


/* Function Prototypes */

void transmit(char output[20], int length);

int receive(char input[20], int length);

void get_position();

int get_time();
```

Trans.h

```
#define WR_ENA 56

#define TST_MODE 57

#define UP_RESET 71

#define TE 70

#define CTS 58

#define DSR 59

#define CONFIG_START_BYTE 0x65

#define PREAMBLE 0x55

#define SYNC 0x3A


char *PORTC=0x07;

char *PORTD=0x08;


void parent_initialize_transceiver(void);

void transceiver_transmit(char data[20], int length);

int transceiver_receive(char data[20], int length);
```

Display.h

```
/* Function Prototypes */
void initialize_lcd(void);

void enable_hl(void);

void line1(void);
void line2(void);
void big_c(void);
void low_h(void);
void low_i(void);
void low_l(void);
void low_d(void);

void low_f(void);
void low_t(void);

void low_o(void);
void low_u(void);
void low_n(void);

void zero(void);
void one(void);
void two(void);
void three(void);
void four(void);
void five(void);
void six(void);
```

```
void seven(void);
void eight(void);
void nine(void);

void space(void);
void block(void);
void pound(void);

void right_arrow(void);
void left_arrow(void);
void up_arrow(void);
void down_arrow(void);
void top_left_arrow(void);
void top_right_arrow(void);
void bottom_left_arrow(void);
void bottom_right_arrow(void);

void check_pan_oor(void);

void cursor_move_left(void);
void cursor_move_right(void);

void display_num(int mult);
void display_distance(void);
void display_direction(void);
void update_direction(void);

void create_arrows(void);
void display_on(void);
```

```
void top_right_arrow(void);
void bottom_right_arrow(void);
void top_left_arrow(void);
void bottom_left_arrow(void);
void down_arrow(void);
void up_arrow(void);

long int get_dir(char dir);

void display_roc(void);

void get_compass(void);
```

Transceiver.h

```
/*  NOTE:  This is for the child device.  The parent device uses
another transceiver.h */

#define TE 68
#define CTS 56
#define DSR 57
#define CONFIG_START_BYTE 0x65
#define PREAMBLE 0x55
#define SYNC 0x3A

char *PORTC=0x07;
char *PORTD=0x08;

void transceiver_transmit(char data[20], int length);
int transceiver_receive(char data[20], int length);
```

Appendix H: GPS Pinouts

Pin number	Function
1	TX from GPS (3 volt)
2	RX from GPS (3 volt)
3	V in = 3V
4	not used
5	Ground
6	3V backup power
7	not used
8	not used
9	5V antenna power
10	not used

Appendix I: Equipment List

PART	PART NUMBER
3 Volt Adjustable Voltage Regulator	LM317T
5 Volt Adjustable Voltage Regulator	7805
Green LED	Radioshack 276-271A
Red LED	Radioshack 276-270A
12 VDC Piezo Mini Buzzer	Radioshack 273-074A
Push ON/ Push OFF Switch	Radioshack 275-1565B
Aerocomm Transceiver	AC1524C-10A (LX2400S-10A)
GPS Receiver	M12 Series
LCD	Optrex PW16433D-CEM-9M
Digital Compass	Densmore 1490
Switches (ON/OFF)	ALCO MTA206N